PETROLEUM INDUSTRY
OF
CALIFORNIA

BULLETIN 69

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CALIFORNIA STATE MINING BUREAU
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OF
California

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BY
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LETTER OF TRANSMITTAL.

March 5, 1915.

To his Excellency, the Hon. Hiram W. Johnson, *Governor of the State of California:*

Sir: I have the honor to transmit herewith Bulletin No. 69 of the State Mining Bureau upon the Petroleum Industry of California.

This report has been prepared with the desire to serve an undoubted and widespread need for detailed information upon our greatest mineral industry. Many thousands of people have been financially interested in the development of our oil resources, and the industrial welfare of California depends, in no small measure, upon their proper exploitation. The economic or financial aspect of the subject has been given particular attention. It is worthy of note that scientific and engineering data form the necessary basis of this report, and particular effort has been made to obtain the most authentic and reliable information.

It is hoped that this publication may call general attention to the fact that careful consideration of details underlies all uniformly successful operations.

Respectfully submitted,

Fletcher McN. Hamilton,
State Mineralogist.

INTRODUCTION.

This work is intended to meet the needs of persons familiar, in a general way, with the oil business and particularly interested in the oil resources of California. It is not expected to fully serve either the person entirely ignorant of the elementary features of the industry, or the expert who is thoroughly informed on any single branch.

Three distinct divisions of the subject are dealt with, as follows:

1. Extent and location of California oil deposits.
2. Cost of extracting oil from the deposits.
3. Marketing and financial conditions governing the oil industry.

It is hoped that the publication will be found useful to three particular classes of men who undoubtedly stand in more or less need of exact information on the oil industry. They are as follows:

1. The small producing companies and their stockholders.
2. The large marketing companies, and particularly the officers dealing with the public.
3. The state and national legislators dealing with the oil industry.

It has been well said and amply demonstrated that success in the oil business depends upon the use of brains, money, and incidentally on luck. Many failures in the business owe their poor position to the reversal of order of application of the three factors, the use of brains being apparently postponed until a final emergency. Too many persons have gone from the height of expectation, where they assumed that unlimited success would follow a rash expenditure, to the depth of despondency, where they assumed that the success of others had only followed dishonesty. As a result we now see a considerable portion of our great natural resource being taken from beneath the earth and disposed of without adequate profit to the producer, some portion of it even leaving the country and being burned entirely to the profit of strangers. Following on the heels of such unprofitable development we see immense quantities of our liquid wealth being absolutely lost because operators are financially unable to properly protect the sands from encroaching floods of water. Most unfortunate of all, we see our producers and marketers engaged in such bitter strife and competition that foreign capitalists are urged to purchase and conduct one of our greatest industries, an abject confession that we lack brains enough to cooperate in an industry supremely and essentially American. It is easily possible that our own national existence might be threatened by allowing this naval fuel to fall into foreign control.

Most officials of large corporations now realize that the public has a right to know considerable about the company affairs. Argument on this point is unnecessary. However, many annual reports to stockholders of large oil companies contain little or no information as to the security or change in value of their investment, and statements to the general public are so rare that every one knows of the exceptions. Such an attitude invites agitation and legislation which may be harmful to every one concerned. An error into which corporation officials may easily fall, being surrounded by a great mass of detailed information, is that their statements must necessarily be correct and that their operation methods are the most efficient. It is easy to be lost in so dense a forest that one fails to see the trees. The statement that large oil companies always operate more efficiently than small ones, is readily shown to be untrue. Their work is necessarily in the hands of some individual and therefore the efficiency of corporations varies almost as widely as does that of individuals. If this publication simply calls attention to the value of technical knowledge and the losses already sustained by failure to use it, a useful purpose will be served.

Cooperation with the State Mining Bureau has almost never been refused by small companies, but the same can not be said of all the large ones.

A complaint that cooperation has been refused would be wholly unfair if no mention were made of the fact that government litigation has undoubtedly frightened and embittered many corporation officials who have always striven to abide by the laws of the land. Legislation upon any subject is certain to be harmful unless sustained by a thorough knowledge of facts. No person, however patriotic, can reasonably maintain that our federal government has been sufficiently well informed upon the oil industry of California to regulate its commercial activity. Furthermore, governmental inquiries, no matter how useful, can readily become burdensome by their frequency, and the state and national governments can doubtless cooperate to a better advantage than they have in the past.

Acknowledgment of assistance has been difficult owing to absurd ideas of secrecy in the oil industry, but wherever possible, note has been made of our obligations.

The work involved in presenting this publication has been particularly pleasant on account of the broad instruction from the State Mineralogist, Mr. F. McN. Hamilton, to gather unprejudiced and interesting facts. Every facility of his office has been disposed to the accomplishment of this purpose.

R. P. McLAUGHLIN.

San Francisco, October, 1914.

TABLE OF CONTENTS.

Chapter I.

Financial Review of Oil Industry during 1913. Summary of Oil Resources of California. Ownership of Proved Oil Land. Geology in Relation to the Oil Industry. Operating Costs, Drilling and Pumping. Marketing and Control of California Oil. Price of Oil. Pages 9–56.

Chapter II.

Productive Capacity of Oil Lands. Underground Movement of Oil. Evaporation Loss of Oil. Temperature Correction in Measuring Oil. Physical and Chemical Properties of California Oils. Some Commercial Uses of Oil. Pages 57–86.

Chapter III.

Pipe Lines. Water Transportation and Exports. Shipments by Rail from California. Reservoirs and Tanks, Specifications and Cost. Refineries. Gasoline from Natural Gas. Gas Production of Various Counties. Pages 87–118.

Chapter IV.

Coalinga Field. Location. History of Development and Rate of Production. Financial Results during 1913. Geologic Summary. Directory of Operating Companies. Drilling Methods and Costs. Cementing. Total Cost of Producing Oil and Method of Computing Land Value. Hauling Cost. Pumping Methods and Costs by Steam, Gas and Electricity. Life of Wells. Water Conditions. Pages 119–194.

Chapter V.

Kern River Field. Location. Topography. Geology. History of Development, and Estimate of Future. Monthly Production since 1903. Financial Results, 1912 and 1913. Directory of Operating Companies. Drilling Cost. Compressed Air to Lift Water. Pages 195–216.

Chapter VI.

Midway-Sunset Field. Location. History of Development and Prospects of Extension.

Midway Field Development and Productiveness. Financial Results, 1912 and 1913. Geologic Summary. Directory of Operating Companies. Drilling Methods and Costs. Production or Pumping Cost. Electric Power. Steam Power. Gas Power. Natural Gas.

Sunset Field Development and Productiveness. Financial Results, 1912 and 1913. Monthly Statistics. Directory of Operating Companies. Life of Wells. Water Conditions.

McKittrick Field. Location. Geology. History. Financial Results, 1912 and 1913. Directory of Operating Companies. Production Cost.

Lost Hills, Belridge and Devils Den Region. Location. Geology. Development. Directory of Operating Companies.

Kern County Production since 1894. Pages 217–307.

Chapter VII.

Los Angeles and Orange Counties. History of Development, Whittier, Fullerton, Coyote, City and Salt Lake Fields, and Future Possibilities. Life of Wells. Annual Production and Price since 1894. Financial Results during 1913. Monthly Production and Well Record since 1903. Directory of Operating Companies. Cost of Pumping or Producing. Cost of Drilling. Geologic Summary. Pages 308–367.

Chapter VIII.

Ventura and Portion of Los Angeles Counties. History of Development. Life of Wells. Annual Production and Price since 1894. Monthly Production and Well Record since 1903. Financial Results during 1913. Directory of Operating Companies. Geologic Summary, with Definition of Formation Names. Pages 368–395.

CHAPTER IX.

Santa Barbara County. (Santa Maria, Lompoc and Summerland Fields.) History of Development and Future Possibilities.

Santa Maria. Geology and Outlying Developments. Monthly Production and Well Record, Santa Maria and Lompoc. Annual Production and Price for Santa Barbara County since 1894. Directory of Operating Companies. Financial Results during 1913. Cost of Drilling. Cost of Pumping.

Summerland. Geology and Directory of Companies. Pages 396–417.

CHAPTER X.

Monterey, San Luis Obispo and San Benito Counties. Geology and Oil Possibilities. Introduction. Geography and Topography. Geology. Stratigraphy. San Lorenzo, Parkfield, Carrizo, Arroyo Grande, Edna, Huasana, San Ardo and Bradley-Pleyto District. Summary. Pages 418–438.

CHAPTER XI.

Notable Oil Occurrences Outside of Proved Areas: Alameda County, Butte County, Colusa County, Contra Costa County, Humboldt County, Imperial County, Lake County, Napa County, Majave Desert Region, Mono County, San Joaquin Valley, North of Coalinga (Vallecitos), San Joaquin Valley, Southern and Eastern Border (Wheeler Ridge, Tejon), San Diego County, Santa Clara and San Mateo Counties, Solano County, Sonoma and Marin Counties. Pages 439–473.

Appendix. Pages 475–496.
Bibliography. Pages 497–508.
Index. Page 509.

PLATES IN FOLIO ACCOMPANYING THIS BULLETIN.

I. Correlation Table.
II. Geologic Map of Portions of Los Angeles and Orange counties.
III. Geologic and Field Map of Portions of Ventura and Los Angeles counties.
IV. Geologic Map of Portions of Monterey and San Luis Obispo counties.
V. Geologic Map of Portions of San Luis Obispo and Kern counties.
VI. Geologic cross sections through Monterey and San Luis Obispo counties.
VII. Map and Gravity Chart of the Coalinga Field.
VIII. Map of the Kern River Field.
IX. Map of the McKittrick and North Midway Fields.
X. Map of South Midway and Sunset Fields.
XI. Map of Midway Field, showing topography, proved area, structural lines and underground contours.
XII. Map of Lost Hills, Belridge and Devil's Den Fields.
XIII. Map of Salt Lake Field.
XIV. Map of Whittier-Fullerton Oil Fields.
XV. Map of Santa Maria Oil Field.
XVI. Plans for Standard and Rotary Rigs.
XVII. Plans for Earthen, Concrete Lined Oil Reservoirs.
XVIII. Map of California, showing pipe lines.

LIST OF ILLUSTRATIONS.

PAGE
The Lakeview Gusher 8
Pioneer Conditions at Midway 18
Hauling Supplies in the Midway Field 28
Lakeview Number Two Well 62
Typical sumps of oil near wells 84
Loading railroad cars with oil at a Standard Oil Company plant 86
Interior of concrete lined earthen reservoir during construction 100
Refinery of Standard Oil Company at Richmond, Cal. 108
Casing worn out by sand carried with oil from a gushing well 120
Portion of Midway Fields showing the town of Taft and the Buena Vista Hills 226
Refinery of General Petroleum Company at Los Angeles, Cal. 316
Summerland Oil Field in Santa Barbara County 406
A burning oil tank at Port San Luis 420

FIGURES.

PAGE
Fig. 1. Map of California, showing possibilities of new oil fields 12
Fig. 2. Diagram showing relation of price, storage, consumption and production of California oil (1895–1913) 48
Fig. 3. Change of Water Level, due to Pumping Well 59
Fig. 4. Possible Change of Oil Level, due to Pumping Wells 59
Fig. 5. Curves, showing Coefficient of Expansion for California Oils of Various Grades, at various temperatures 80
Fig. 6. Flow Sheet for Casing Head Gasoline Plant 114
Fig. 7. Diagram showing Rate of Development and Production in Coalinga Field 126
Fig. 7A. Geologic Map of Coalinga Oil Field 140
Fig. 7B. Geologic cross sections in Coalinga Oil Field 132
Fig. 8. Production Record of 36 Coalinga Wells 168
Fig. 9–26. Production Records of groups of Coalinga Wells 170–187
Fig. 27. Diagram showing Rate of Development and Production in Kern River Oil Field 203
Fig. 28. Diagram showing Rate of Development and Production in Midway Oil Field 220
Fig. 28A. Chart showing proved Oil Land and Gravity of Oil in Midway-Sunset Oil Field 222
Fig. 29. Geologic cross section through Twenty-five Hill, in Midway Field 229
Fig. 30. Geologic cross section through the Midway Field 230
Fig. 31. Production of some Midway Gas Wells 252
Fig. 32. Diagram showing Rate of Development and Production in Sunset Oil Field 257
Fig. 33–52. Production Record of Groups of Wells in Midway Field 268–287
Fig. 53. Diagram showing Rate of Development and Production in McKittrick Field 294
Fig. 54. Diagram showing Rate of Development and Production in Lost Hills and Belridge Oil Fields 304
Fig. 55. Diagram showing Rate of Development and Production in Whittier-Fullerton Field 309
Fig. 56. Diagram showing Rate of Development and Production in Whittier Oil Field 310
Fig. 57. Diagram showing Rate of Development and Production in Fullerton-Brea Canyon Oil Field 311
Fig. 58. Diagram showing Rate of Development and Production in Los Angeles City Oil Field 312
Fig. 59. Diagram showing Rate of Development and Production in Salt Lake Oil Field 313
Fig. 59A. Proved Oil Land and Gravity of Oil in Whittier-Fullerton Field 314
Fig. 60–66. Production Records of Groups of Whittier-Fullerton oil wells 318–324
Fig. 68. Geologic cross section in Beverly Hills Field 357
Fig. 69. Geologic cross section in La Habra Field 361
Fig. 70. Geologic cross section in Coyote Hills Field 363
Fig. 71. Diagram showing Rate of Development and Production in Ventura County Oil Field 370
Fig. 72. Diagram showing Rate of Development and Production in Santa Maria Oil Field 397
Fig. 73. Diagram showing Rate of Development and Production in Lompoc Oil Field 398
Fig. 73A. Proved Oil Lands and Gravity of Oil in Santa Maria Oil Field 399
Fig. 74–75. Production Record of Wells in Santa Maria Oil Field 400–401
Fig. 76. Geologic cross section in Santa Maria Field 404
Fig. 77. Portion of Humboldt County, showing oil occurrences 446
Fig. 78. Geologic Map of Vallecitos District 464

THE LAKEVIEW GUSHER.

During eighteen and one half months it produced ten million barrels of oil of which only six million were saved. Photograph by R. B. Moran.

CHAPTER I.

FINANCIAL REVIEW OF OIL INDUSTRY.

A review of the financial and operating conditions of the various California oil fields during 1913 is afforded by the following table. To those not familiar with the difficulty in gathering such information it may be well to state that obtaining absolutely accurate figures is an impossibility. However, several separate sources of information have here been consulted and the figures are believed to be fairly representative.

Only *producing companies* (totaling 276) were considered. There are some 800 incorporated oil companies in the state, but many have never been active.

Capital, as shown by the figures, is not definite, but aims to include all payments for stock. The cash column is probably fairly accurate but that showing property is probably a great deal too large.

Dividends, as shown, are certainly not overestimated. They roughly indicate the profitableness of the business, but it must be borne in mind that many prosperous concerns reinvest their profits without paying dividends, which probably explains the fact that prices and operating costs appear to vary so slightly between dividend and non-dividend companies.

Price of oil, as shown by these figures, clearly demonstrates that only in exceptional cases is oil production profitable when less than 40 cents per barrel is received.

Operating cost is here so tabulated as to bring out the operating difference between fields, in the column of cost per well per day. This method of comparing costs is the only way for an operator to determine whether costs are reasonable. A little thought given to the subject will show the absurdity of the custom of quoting only costs per barrel produced. Two properties might be equally well managed, but if one had very productive wells and the other only small producers, cost figures per barrel would show only the difference in productiveness and not the difficulty of operation nor effectiveness of management.

The operating cost does not here include such fixed charges as depreciation, taxes, or insurance, but does include the drilling of new wells and overhead charges, such as officers' salaries. These cost figures are only general and the subject is more fully treated in the body of the book.

Marketing companies make up most of the figures listed as miscellaneous. Comparison of their dividends and capital with those of the producing companies indicates that there is nearly an equal division of profits between the two branches of the industry, and that larger profits to both would be wholly justifiable in view of the hazardous nature of the business.

Financial and Operating Conditions of California Oil Fields, 1913.

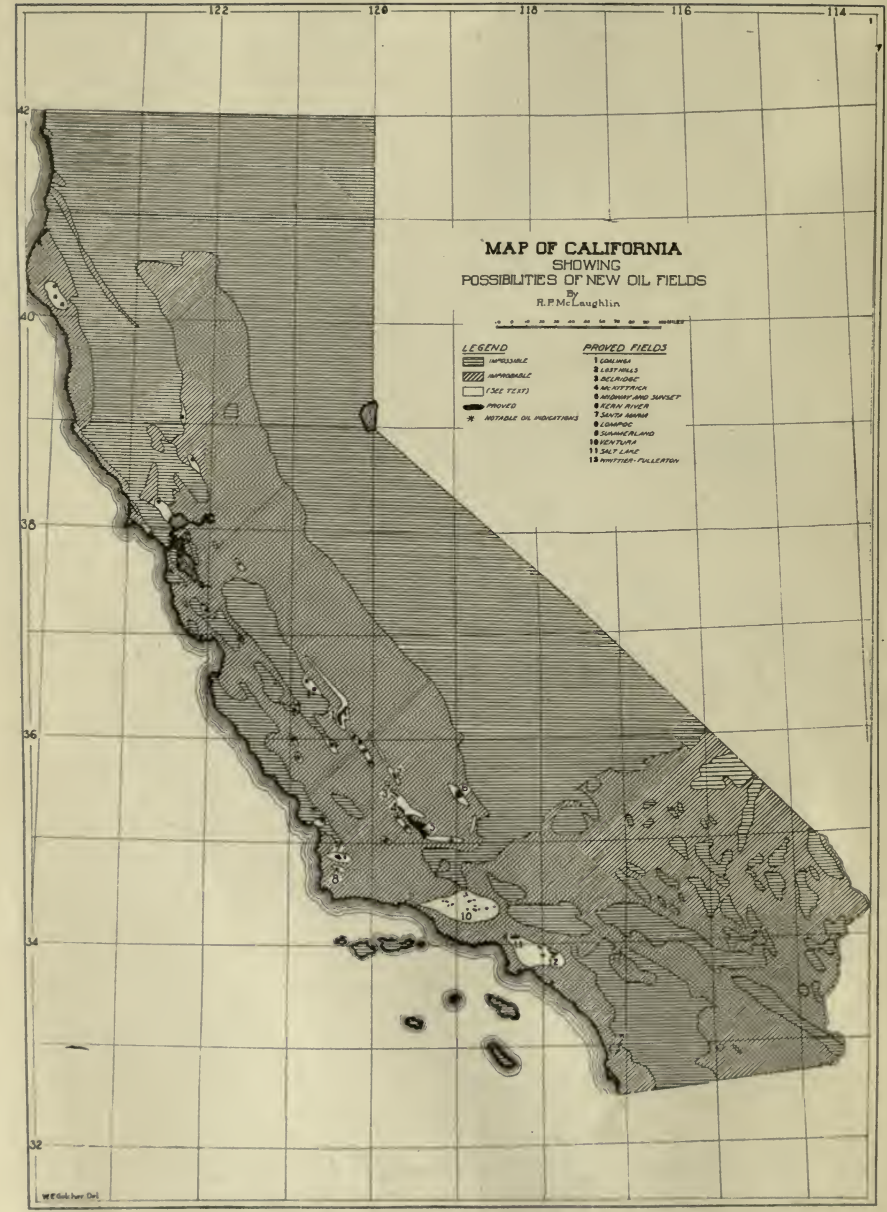
Field	Number of companies considered	Total field product, 1913, barrels	Product of companies considered, barrels	Per cent of field production	Capital	
					Cash	Property
Coalinga	59	18,604,626	11,681,164	63	$8,087,785	$9,634,512
Kern River	50	9,980,940	4,208,231	42	5,198,416	3,520,029
Midway	59	33,040,129	15,861,884	48	3,891,763	12,110,051
Sunset	22	5,984,651	2,120,262	35	1,046,297	5,716,563
McKittrick, Belridge and Lost Hills	14	9,771,395	5,316,697	54	794,859	8,164,292
Santa Maria, Lompoc and Summerland	12	5,817,711	1,940,980	33	2,454,943	19,613,135
Ventura County	21	902,273	656,171	73	1,016,254	4,550,464
Los Angeles and Orange counties	27	13,677,958	5,319,816	39	4,247,826	7,329,343
Sub-totals	264	97,779,683	47,105,205	48	$26,738,143	$70,638,389
Miscellaneous (including marketing companies)	12	----------	35,561,347	--------	68,134,840	47,892,543
Grand totals	276	97,779,683	82,666,552	85	$94,872,983	$118,530,932

Financial and Operating Conditions of California Oil Fields, 1913—Continued.

Field	Dividends									
	1909		1910		1911		1912		1913	
	Companies	Value	Companies	Value	Companies	Value	Companies	Value	Companies	Value
Coalinga	17	$1,287,244	16	$1,366,243	14	$1,236,338	15	$1,154,328	17	$956,098
Kern River	22	1,123,129	24	392,472	22	389,822	26	454,095	19	361,444
Midway	4	101,000	10	562,763	18	1,076,285	19	1,128,161	14	520,520
Sunset	3	21,527	5	127,212	7	211,339	7	319,220	3	91,936
McKittrick, Belridge and Lost Hills	2	269,795	2	239,750	1	85,000	2	134,945	6	538,744
Santa Maria, Lompoc and Summerland	4	894,125	5	1,548,236	5	1,000,141	6	374,720	8	500,976
Ventura County	1	11,790	1	22,067	2	46,252	2	26,393	2	54,720
Los Angeles and Orange counties	12	1,203,556	13	1,427,908	12	1,288,034	12	878,478	14	3,015,159
Sub-totals	65	4,912,166	76	5,686,651	81	5,333,211	89	4,470,340	83	6,039,597
Miscellaneous (including marketing companies)	6	10,440,331	6	2,981,598	5	2,830,403	7	4,401,218	8	9,509,009
Grand totals	71	15,352,497	82	8,668,249	86	8,163,614	96	8,871,558	91	15,548,606

Financial and Operating Conditions of California Oil Fields, 1913—Continued.

Field	Under 18° Baume		Over 18° Baume		Average price, cents per barrel	Price to dividend companies, cents per barrel	Operating cost					
							All companies			Dividend companies		
	Per cent	Price	Per cent	Price			Barrels per well per day	Per well day	Cents per barrel	Barrels per well per day	Per well day	Cents per barrel
Coalinga	55	$.35	45	$.508	42.5	47.6	54	$10 96	20.2	65	$11 70	17.9
Kern River	100	--------	--------	--------	32.8	32.7	13	2 64	20.2	26	2 73	9.6
Midway	38	--------	62	--------	49.0	52.1	69	10 89	15.6	64	11 18	17.5
Sunset	12	.361	88	.534	35.2	50.0	50	10 29	20.4	--------	--------	28.5
McKittrick, Belridge and Lost Hills	25	--------	75	--------	47.0	45.7	63	6 87	10.9	65	6 24	9.5
Santa Maria, Lompoc and Summerland	14	.379	86	.56	53.5	44.5	40	4 65	11.6	50	5 15	10.2
Ventura County	8	.46	92	1.06	101.0	--------	10	3 63	36.5	--------	--------	--------
Los Angeles and Orange counties	27	.555	73	.758	70.0	--------	30	5 76	19.1	--------	--------	--------


MAP OF CALIFORNIA
SHOWING
POSSIBILITIES OF NEW OIL FIELDS
By
R. P. McLaughlin
MILES
LEGEND
IMPOSSIBLE
IMPROBABLE
(SEE TEXT)
PROVED
NOTABLE OIL INDICATIONS
PROVED FIELDS
1 COALINGA
2 LOST HILLS
3 BELRIDGE
4 MC KITTRICK
5 MIDWAY AND SUNSET
6 KERN RIVER
7 SANTA MARIA
8 LOMPOC
9 SUMMERLAND
10 VENTURA
11 SALT LAKE
12 WHITTIER-FULLERTON
122
120
118
116
114
42
40
38
36
34
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W. E. Gelcher Del.

Fig. 1.

SUMMARY OF OIL RESOURCES.

Comparison of the size, degree of development and productiveness of the various fields is afforded by the following table:

Size, Development and Productiveness of California Oil Fields.

Field	Proved land		Wells producing	Acres per well	Total production to end of 1913, barrels	Barrels per acre, to date	Monthly decline per well per day, barrels
	Square miles	Acres					
Coalinga	22.0	14,100	915	15.4	138,744,751	9,840	.52
Kern River	10.1	6,450	1,675	3.9	167,357,375	25,900	.32
McKittrick	1.4	895	270	3.3	37,103,169	41,450	1.33
Midway and Sunset	59.0	37,800	1,222	30.8	94,566,895 31,991,216	3,350	.71 1.03
Belridge and Lost Hills	4.1	2,620	185	14.2	8,175,612	3,110	5.00
Salt Lake	1.7	1,080	299	3.8	27,753,380	24,350	.37
Los Angeles City	.6	380	†400	.4	16,700,000	40,170	
Whittier-Fullerton	4.7	3,010	514	5.8	59,007,620	19,600	increase
Ventura§	2.5	1,600	332	4.8	12,482,947	7,800	(high)
Santa Maria	5.18	3,320	191	17.3	57,006,426	17,200	1.8
Lompoc	1.8	1,150	30	38.2	4,360,473	3,810	
Summerland	.2	130	‡150	.2	1,801,594	20,250	
	113.3	72,535	6,183		657,051,458	*9,050	

†1,000 original, some abandoned.
‡412 original, some abandoned.
§Very general figures.
*Average.

Proved oil land is that which has been shown, principally by finished wells, and incidentally by geologic data, to be such that other wells drilled thereon are fairly certain to be commercial producers. The areas as here computed were obtained by first carefully outlining such lands upon the maps which accompany the detailed descriptions of the various fields.

Producing wells are surprisingly difficult to accurately account for as different enumerators disagree, and furthermore, the figure is constantly changing.

The area per well, as shown in the table, is obtained by simply dividing the proved area of the field by the number of wells. This figure gives a very good idea of the extent to which the various fields have been drilled, if one bears in mind that from four to eight acres per well is the economic limit.

Total production to the end of the year 1913 is believed to be shown in the above table as nearly correct as is possible.

Production per acre to date is one of the most valuable figures in the table, as it affords a clue towards estimating the ultimate production. It seems fairly certain that the various fields will differ greatly in their ultimate production, but a few are now so nearly exhausted that the reader may gain a very definite notion of it by carefully considering the detailed field descriptions and their rates of decline.

The rate of decline, as just previously indicated, is more fully dealt with in the descriptions of individual fields. It is such an important factor, and dependent upon so many variables, that any short explanation would be wholly misleading.

Maps of the producing fields are published in the folio accompanying this volume. They show the stage of development about July, 1914. They are compiled from all available maps and corrected during the course of our field work. It would be impossible to credit any map to a single source but we owe thanks to the following individuals and companies:

Standard Oil Company.
Union Oil Company.
General Petroleum Company.
Associated Oil Company.
Universal Oil Company.
Kern Trading and Oil Company.
M. J. Kirwan, Coalinga.
E. B. Latham, Taft.
R. J. McFadden, Anaheim.
A. Abbey, Taft.

The extent of probable oil land in California might be estimated, but a more useful purpose will be served by calling attention to the fact that vast areas of land have not yet been carefully examined, therefore a correct geological map of the state can not be made. Estimates of oil reserves, when not based upon observed facts, have usually been shown by developments to be ridiculous. The accompanying sketch map (Fig 1), shows approximately the territory which, from present accounts, seems impossible as oil land, being mostly igneous and metamorphic rock. It also shows the area which present information indicates as improbable oil territory. A great deal of the remaining area will in all probability never produce oil but it is particularly worthy of note that the proved land comprises only a very small part of this unclassified area, and therefore considerable expansion of our proved area is not impossible. Careful reading of published geological reports indicates that developments have already exceeded expectations in numerous and important instances. On the other hand it seems probable that most of the easily recognized indications of possible oil fields have now received some attention from geologists or prospecting drillers. Our detailed descriptions of the various fields give some data upon probable extensions.

Ownership of proved land and completed wells, by the various marketing and producing concerns, is shown in the following table

---

*See pages 57 and 125.

(summarized from data appearing throughout this publication). Careful consideration of the figures bring out the following very striking facts:

1. There is no monopoly in ownership of proved oil lands, miscellaneous producers holding 36 per cent of the land and the largest individual holding being that of the Kern Trading and Oil Company (Southern Pacific Railroad), with 23 per cent. Ownership of land by the three largest marketing companies is equally divided, each having about 8 per cent, and the agency slightly more.

2. Production by all parties is almost in direct proportion to their ownership of land, the principal exception to this being the Kern Trading and Oil Company, which has for several years been drilling only in defense of its boundary lines against off-setting wells.

3. Degree of development varies greatly, the least developed holding being that of the Kern Trading and Oil Company which has one well for about thirty acres of land. The Standard Oil Company and Union Oil Company come next with eighteen and fifteen acres, respectively. Others fall as low as six. While these figures take no cognizance of the degree of exhaustion of the various holdings, they do give a very definite idea of the future development and productive strength of the various concerns.

COMPARISON OF OWNERSHIP OF PROVED OIL LAND AND COMPLETED WELLS.

Various Marketing and Producing Concerns in the California Oil Fields, 1914.

	Standard Oil Company			Union Oil Company			Independent Oil Producers Agency			Associated Oil Company and affiliated companies		
	Wells	Acres per well	Acres	Wells	Acres per well	Acres	Wells	Acres per well	Acres	Wells	Acres per well	Acres
Coalinga	76	8.4	640	18	8.9	160	353	9.7	3,420	50	8.2	410
Kern River							392	1.9	760	388	6.6	2,550
McKittrick							57	3.6	205	84	5.4	460
Midway and Sunset	98	36.2	3,650	64	15.3	980	259	8.3	2,150	31	41.6	1,290
Belridge and Lost Hills	39	7.7	300							9	4.4	40
Salt Lake										162	5.5	890
Los Angeles City												
Whittier-Fullerton	22	31.4	690	55	10.3	570				64	4.4	280
Ventura and Newhall	64	3.9	250	97	4.1	400						
Santa Maria				125	27.5	2,390						
Lompoc						1,050						
Summerland												
Total acres			5,530			5,550			6,535			5,920
Per cent of California proved land			7.6			7.7			9.0			8.2
Total wells completed	299			359			1,061			788		
Average acres per well		18.5			15.3			6.2			7.5	
Per cent oil produced, July, 1913			9.4			*17.6			†			10.3
Per cent oil controlled, July, 1913			28.6			*21.8			†			25.7

*Including Agency.
†See Union.

COMPARISON OF OWNERSHIP OF PROVED OIL LAND AND COMPLETED WELLS—Continued.

	K. T. & O. (S. P.)			General Petroleum Company			Santa Fe Railroad			Other producers			Total		
	Wells	Acres per well	Acres	Acres	Acres per well	Wells	Wells	Acres per well	Acres	Wells	Acres per well	Acres	Wells	Acres per well	Acres
Coalinga	151	24.1	3,640	21	11.5	240				467	12.0	*5,590	1,136	12.4	14,100
Kern River	229	1.9	440				108	1.3	240	775	3.2	2,460	1,892	3.4	6,450
McKittrick	48	2.4	115							54	2.1	115	243	3.7	895
Midway and Sunset	119	115.8	12,600	114	11.9	1,360	118	28.4	3,350	804	15.5	12,420	1,607	23.6	37,800
Belridge and Lost Hills			80	45	8.9	400				92	19.6	1,800	185	14.2	2,620
Salt Lake										137	1.4	190	299	3.8	1,080
Los Angeles City										400	.9	380	400	.9	380
Whittier-Fullerton				35	1.4	50	70	2.7	190	305	4.0	1,230	551	5.5	3,010
Ventura and Newhall										171	5.6	950	332	4.8	1,600
Santa Maria										144	7.2	930	269	16.6	3,320
Lompoc												100			1,150
Summerland	10		20							140	.8	110	150	.9	130
Total acres			16,895			2,050			3,780			26,275			72,535
Per cent of California proved land			23.3			2.8			5.2			36.2			
Total wells completed	557			215			296			3,489			7,064		
Average acres per well		30.4			9.5			12.8			7.5			10.3	
Per cent oil produced, July, 1913			8.4			4.5			4.9			44.9			
Per cent oil controller, July, 1913			10.3			4.0			5.4			4.2			

*Including Agency.

Pioneer conditions at Midway. Rush of teams with material for rigs on claims located under placer law. Photograph by R. B. Moran.

GEOLOGY.

Our treatment of this subject has been only with the view of more definitely describing the oil deposits, and not that of purely scientific research. We have been particularly fortunate in receiving assistance from some of the best informed oil geologists in California, and have also been able to draw from many excellent publications. Several areas not previously mapped have been examined and maps are here presented. The detail of a large portion of our geologic work has been done by Mr. Clarence A. Waring.

Geology being a study of natural earth conditions of course offers the only logical channel for consideration of oil deposits and any failure of geologic predictions merely represents the natural hazard of the industry.

Nearly all the larger operating concerns in California now systematically collect geological information as the initial step in the investigation of a property.

THOROUGH GEOLOGIC STUDY OF A REGION MAY REASONABLY BE EXPECTED TO ANSWER THE FOLLOWING QUESTIONS:

1. Is the region or any part of it likely to produce oil? (Enough money has already been wasted in drilling wells in *absolutely impossible* territory, to have paid for making a map of California showing pretty definitely the areas of possible oil land.)
2. What particular portions of the region offer the best possibilities?
3. How great a thickness of sand exists and is likely to contain oil?
4. At what depths do such sands lie below the ground surface?

It will readily be seen that in answering the above questions no public survey can devote the time or money to definitely classify each and every small tract of land.

A public survey should furnish enough general information to determine whether a detailed examination is justified, and if so, the detailed examination of a particular tract can then be made in much less time and at less cost than would otherwise be possible.

SOME QUESTIONS THAT CAN NOT BE ANSWERED FROM GEOLOGICAL EXAMINATION OF AN UNDEVELOPED REGION ARE AS FOLLOWS:

1. Does an outcropping sand, certainly contain oil at depth?
2. What amount of oil does a given tract of land contain?
3. What gravity of oil is contained in a given tract of land?

Statements in this publication which deal with undeveloped territory and are based upon geological evidence, are subject to the above stated conditions which must be clearly borne in mind.

One of the best illustrations of the value of a geologist's opinion, expressed after careful examination of land, is the correctness of the following statement made by S. F. Peckman at the early date of 1866. (Geology of California, Vol. 2, Appendix, p. 49. Cambridge, Mass., 1882.)

"To speak seriously of the 'Oil Interests of Southern California' draws forth from the majority of the citizens of this state a smile of incredulity or ridicule. To urge their claims to consideration as a field for profitable investment presents to most men strong reasons for doubting your sanity. Yet the southern portion of this state has veritable oil interests, which only need the fostering care of men of sound judgment, aided by sufficient means, to enable this section to ultimately furnish this entire Pacific coast with both illuminating and lubricating oils, at prices that will render futile all competition of eastern products."

Erroneous conclusions were drawn by some of the earliest observers in California, due largely to the fact that they had made only a very limited examination of the territory. No public surveys had then furnished the general information which is now so freely distributed and used. The present wide distribution of geologic information is apt to cause one to overlook the difficulty in collecting it and to forget the many faithful and poorly paid workers to whom we are indebted for commercially valuable knowledge, based on scientific facts. Attention is particularly directed to the fact that many portions of California have not yet been thoroughly described or mapped.

A consideration of certain elementary features of the science of geology is necessary in order that a clear idea of oil deposits may be gained.

All rocks are divided into three classes, igneous, metamorphic and sedimentary.

Igneous rocks are those which have passed into their present solid state, from a previous molten or nearly molten state. It is readily seen how absurd it would be to expect a mineral so volatile as oil to form in an igneous formation, although in rare cases it has afterward collected in fractured igneous rocks.

Metamorphic rocks are those which have been intensely folded, crushed, or altered by percolating solutions until the texture, crystalline structure, or mineral constitution is changed. To this class of rocks belongs the Franciscan series, in which the sandstones have been crushed and altered until the grains are elongated and new minerals formed. The shales have been metamorphosed by pressure into slates, and by change of mineral composition into chert and jasper. The former water-worn minerals have lost their form and their content has been utilized in the formation of new minerals.

The intense folding and fracturing to which this class of rocks has been subjected has left few definite and extensive reservoirs in which oil might accumulate. Small amounts of oil have been reported in fractured Franciscan rock, but none has been produced in commercial quantities.

Sedimentary rocks are those which have been deposited in water. The ocean, lakes and rivers are constantly changing in shape and position. The greatest amount of sediment carried by streams is deposited along the sea coast where conglomerate, sandstone, shale and limestone are laid down in the varying depths of water. The pressure of these sediments along the shore line causes a folding of the older sediments along an axis parallel with the coast, accompanied by a hardening of the beds.

The sedimentary rocks are of chief interest in the oil industry as the occurrence of oil is limited, with few exceptions, to them. In other words, all the oil fields of California were once covered by the ocean.

Geological names applied to certain formations are used in the attempt to classify them with reference to their relative age. (See Plate I.) Geological time can not be measured in years but merely states the order in which formations have been deposited. Local names are applied to formations before their ages, relative to the standard series, are known. When enough field work is done a local formation is frequently found to correspond in whole or in part to some other formations which have been previously observed and classified. The above mentioned drawing, of the formations in the California oil fields, shows the relation of local formations to each other, as far as present knowledge extends.

Fossil remains, of land or water animals and plants, occur in nearly all sedimentary rocks but are not an indication of the presence of oil. They are, however, extremely valuable in determining the geologic ages of formations. Detailed study has shown that certain animal and plant remains are found to occur almost exclusively in certain formations. Therefore reversal of the order of observation enables one, thoroughly versed in the subject, to determine from given fossils the relative age and position of the formation containing them. Identification of fossils is simplified by comparison with illustrations published by scientific organizations, or with complete collections in museums. The correlation table (Plate I) in the accompanying folio gives the pictures and names of several fossils which have been found to be characteristic of the various California formations.

A glance at the correlation table will show that oil is not confined to any single California formation but occurs in almost all of them later then (or above) the lower Cretaceous.

Therefore the problem of locating a possible oil-bearing formation does not depend upon finding a formation of definite age, or bearing certain fossils. The work of the geologist is, rather, that of collecting all possible evidence as to composition, thickness and position of various formations in the area under investigation. This work means tedious and painstaking observation and recording of all outcrops and also study of logs of wells. Such evidence is usually best exhibited by accurately made drawings. All the evidence that can be collected sometimes makes an incomplete case and a conclusion drawn depends upon the judgment of the person doing the work. A person who has had experience in various regions has the best fund of knowledge from which to draw conclusions. As in all other classes of work there are individuals who improperly assume the title of geologist, but a careful investigation usually reveals the man's value. A thorough geologist is not necessarily informed in other branches of the oil business.

This description of the work of an oil geologist should make it clear that he follows the same line of investigations as does any well informed oil man. The only advantage he has is that accruing to any worker who, by practice or study, thoroughly understands how to make the very best use of the tools placed in his possession.

Structure of the geologic formations (their attitude or relative positions), is of vital importance. After sedimentary beds have been laid down they are frequently bent, folded or broken and it can not be too strongly emphasized that underground formations do not necessarily lie parallel to the ground surface nor to each other, although they sometimes do. Various structural details have definite names and a few of those most commonly used will be briefly defined.

Anticline. A fold in stratified rock in which the convex side is upward, thus forming a ridge in the formation but not necessarily on the land surface.

Syncline. A fold in stratified rock in which the concave side is upward, thus forming a trough in the formation, but not necessarily on the land surface.

Monocline. A bending in stratified rocks which causes them to dip in only one direction. The beds sometimes continue horizontally on either side of the monocline.

Fault. A break in stratified rock caused either by intense folding or intrusions of molten rock. Earthquakes are probably sometimes caused by and accompany movement of the rock along a fault. Faults often account for the incontinuity of strata.

"Break" is not a technical term. It is frequently used in the oil fields to designate an outcrop of oil sands, and does not signify faulting.

Strike. The compass direction horizontally along an outcropping stratum.

Dip. The angle of slope of a formation. Its direction is necessarily at right angles to the strike and is measured in degrees from the horizontal.

Uncomformity. A break in the deposition of sediments of two formations. After a period of sedimentation, conditions may change so that there is no longer a deposition of sediments, and the beds may be tilted or exposed to erosion. When sediments are again deposited by another change in conditions, the new strata will be laid down horizontally and unconformable with the older sediments. This process may go on indefinitely and we often have unconformities between strata, none of which are horizontal.

Terms without strict technical meaning but frequently occurring in logs and in drilling practice:

Water-sand and oil-sand. Sandstone strata which carry water or oil are referred to as water-sand and oil-sand respectively, just as a pitcher which is used for water may be termed a water-pitcher, while if it is used for milk it is termed a milk-pitcher. The same stratum may carry either water or oil in different localities, and although logs of adjacent wells may be correlated, logs of wells at considerable distance apart often show a single sand, carrying oil in one place and water in another place. A thoroughly washed sample of sand has nothing to show in which class it belongs.

Shell. Most hard rock which causes slow drilling is called ''shell.''

Boulders. When standard tools are used this term is probably properly applied to loose, hard rocks which are drilled through with difficulty. When rotary tools are used the term is applied to any hard rock which causes the bit to jump.

Conglomerate. This term is seldom used in the strict geologic sense, which means rock consisting largely of water-worn pebbles. It is commonly used for any mixture of sand, clay, gravel, pebbles, boulders, shell, etc.

Top-water and bottom-water. These terms are applied to the water-sand in its relation to the oil-sand. If the water is in a sand lying *above* the oil-sand it is termed top-water. If the water is in a sand lying *below* the oil-sand it is called bottom-water. The top-water in one well may be the bottom-water in another well, because of the overlapping of the geologic formations, hence the terms are very indefinite.

ORIGIN AND ACCUMULATION OF PETROLEUM.

Petroleum in California is thought to be the product of a slow and little understood process of metamorphism and distillation affecting the hydrocarbon material in diatoms and other organic remains which are so abundant in certain shales of the tertiary system. The distilled product accumulates in the fractures of the shale and is frequently driven by water horizontally and upward till it is retained by impervious strata. When lenses and beds of sandstone underlie impervious strata of shale, clay or limestone they provide suitable reservoirs for the accumulation of petroleum. A sandstone lens overlain by shale, or a sandstone bed capped by shale in an anticline or dome are favorable to the accumulation of petroleum in "pools." The position of petroleum in a formation is often influenced to a great extent by invading waters. (See also page 201, Kern River.)

OPERATING COST.

An industry directly dependent upon the development of some natural resource, as are all the branches of mining, passes through a period of extravagance and wastefulness. Blame is not necessarily attached to those operating under such conditions because the law of supply and demand operates in all commercial enterprises, and when a product is being turned out lavishly its value is forced down. Under such conditions the most profitable operation is that of turning out a large amount of the product and the operator who pauses to consider the cost may thereby lose more than he saves. The past ten years has been such a period of extravagance and wastefulness in the California oil industry. New territory has been opened with large wells and the race to gain title to new properties has been the cause of reckless expenditure and speculation. The pioneers who have proved the lands to be oil bearing have frequently had their original investment returned with hundreds or possibly thousands per cent profit by selling the proved land or a part of it. The hazard has been roughly proportionate to the profits.

These conditions are becoming less common as the amount of unprospected lands diminishes and the readily available markets for oil have been filled. The later conditions are based upon less hazard and smaller profit which call for more careful attention to engineering and business details.

Our figures upon drilling and pumping costs are presented with the view of directing attention to this important feature of the industry which has received little or no public recognition. Some of the obstacles we encountered in gathering these figures should disappear in the near future, if this publication serves its intended purpose. Some of the chief difficulties encountered were: lack of uniformity in accounting, inattention by small operators, and secretiveness of most large companies.

On the other hand we have been most cordially aided by many operators who have merely requested that their names should not be published. This feature of anonymity has made our figures less useful than they otherwise would be, because knowledge of local conditions is an important factor.

One of the most surprising features presented by study of our figures is that the heavy, or least valuable oils, are the most expensive to produce after wells are completed.

DRILLING COST.

The cost of drilling wells in California differs greatly in various fields and even in different parts of a single field. The following table illustrates the variation and emphasizes the fact that general statements are useless.

Approximate Drilling Costs per Foot for Different Depths and Fields.

	1000 feet			2000 feet			3000 feet		
	Labor	Material	Total	Labor	Material	Total	Labor	Material	Total
Coalinga	$2 02	$9 68	$11 70	$2 34	$9 15	$11 49	$1 90	$9 18	$11 08
Kern River	1 90	5 00	6 90						
Midway, Sunset and McKittrick	1 16	6 40	7 56				2 48	8 38	10 86
Santa Maria							1 69	2 72	4 41
Ventura	1 54	2 67	4 21						
Los Angeles and Orange				78	3 03	3 84	2 22	7 50	9 72

Accompanying the detailed description of each field are figures intended to show usual drilling rate, or speed, and the amount of casing used, as these are the two important factors in drilling costs. These figures can be greatly improved in the future if operators will give attention to the subject of cost on their own and other properties. Doubtless managers will sometime be judged largely by their ability to maintain low working cost.

PUMPING COST

The cost of pumping wells is even more important than drilling as the expenditure extends over a long time. Our figures were collected with the idea of showing (1) equipment cost, (2) operation cost, and (3) repair cost, but such a division is very difficult to make owing to the absence of uniformity in various accounting systems used. It was also hoped that figures would show a comparison of the relative advantages of steam, gas, and electricity, in pumping, but other confusing factors are so important that a final statement is not warranted. However, when gas is utilized, which would otherwise be wasted, the cost is of course lower than with any other source of power.

Some of the factors causing such wide variations in pumping costs are: difficulty in maintaining or repairing wells, life of pumps, number of wells in an operating unit, water troubles, gravity of oil and depth of wells.

Equipment cost is fairly uniform in various fields and for the various kinds of motive power used. An average per well is possibly $1,200.00, but reference to detailed accounts will show the reader the variation in this figure.

Operation cost is largely influenced by the number of wells attended by a crew or, in other words, by the compactness of the group of wells. It will be seen that this figure varies from $0.90 to over $5.00 per well per day, and that the stating of an average figure is not possible. Pumping by means of power heads and jacks is far below the above expressed minimum.

Emphasis should be laid upon the fact that accounts, in order to give any idea of the efficiency of operation, should show the cost of operation *per well* and not *per barrel.* Statement of the cost per barrel of oil is of course also necessary for other purposes.

Repair costs vary greatly on account of behavior of various wells, particularly with reference to the amount of sand entering them. Some wells need cleaning several times per month, while others pump for years without attention. Life of pumps also varies within as wide limits. Figures here presented show repair cost per well per day to vary from $2.00 to $0.35 or even lower.

All the operating and repair costs of pumping wells, exclusive of overhead charges, vary from a few cents to over $10.00 per well per day. This figure must not be confused with that shown in the financial reviews, here presented, which include drilling and all overhead charges, except fixed charges, such as taxes, insurance, interest and depreciation.

Hauling supplies in the Midway Field.

MARKETING OF CALIFORNIA OIL.

Usually the producer of California oil sells and delivers it at the wells and the purchasers of most of the oil are limited to a few large concerns, equipped with pipe lines, tank cars, tank vessels, refineries and retail stations. The means of transporting and refining are of course essential to the success of the marketers, but doubtless their most important asset is the retail system and sales force.

The names of the marketing concerns, with the amounts of oil taken from their own properties, amounts purchased, and the totals for 1912 and the first half of 1913 are given in the following list, which is compiled from evidence presented before the Railroad Commission of California. Detailed figures of more recent date were not available.

The Santa Fe and Kern Trading and Oil companies, although here listed as marketing concerns, should not be so considered, as their principal function is that of supplying fuel to the Atchison, Topeka and Santa Fe and Southern Pacific railroads.

It is particularly worthy of notice that the real marketing concerns, including the Union-Agency, produce only 42 per cent of the total oil production. The marketing concerns, exclusive of the agency, produce only 30 per cent of the total. The marketing concerns and the railroads produce 55 per cent of the total.

Control of California Production.

By—	July, 1913		
	Produced barrels	Purchased barrels	Total, barrels
Standard	751,906	1,552,029	2,303,935
Union-Agency	1,414,269	370,405	1,784,674
Associated	564,840	949,592	1,514,432
Kern Trading and Oil Company	678,302	134,431	812,733
General Petroleum	362,559	185,275	547,834
Santa Fe	397,143	----------	397,143
Amalgamated	260,965	86,660	347,625
Miscellaneous	----------	318,969	318,969
State	4,429,984	3,597,361	8,027,345
First half 1913 average	126,664	117,923	244,587
First half 1912 average	102,876	128,081	230,957

Control of California Production.

By—	First half of 1912, barrels	Per cent of total	First half of 1913, barrels	Per cent of total
Standard	12,775,473	31.07	12,672,122	28.64
Union-Agency	8,122,245	19.75	9,640,444	21.78
Associated	10,249,305	24.94	9,169,453	20.71
Kern Trading and Oil Company	3,177,330	7.72	4,554,093	10.29
General Petroleum	----------	----------	1,771,050	4.00
Santa Fe	2,160,424	5.25	2,376,541	5.38
Amalgamated	2,114,923	5.14	2,228,747	5.03
Miscellaneous	2,524,149	6.13	1,857,803	4.17
Totals	41,123,849	100.00	44,270,253	100.00

STANDARD OIL COMPANY

The Standard Oil Company entered California about 1902. It has pipe lines from all the San Joaquin Valley fields to its refinery at Richmond on San Francisco Bay, also pipe lines from the fields near Los Angeles to its refinery at El Segundo, and lines from Ventura County and Santa Maria deliver oil to its ocean going tank steamers. The following figures show the sources of its oil supply, about one third of which it produces from its own property.

It will be noticed that this company purchases little or no oil heavier than 18° B., or even 20° B., preferring the lighter oils which are more suitable for refining, consequently it enters the fuel market only in disposing of the residuum from the refineries.

STANDARD OIL COMPANY CONTROL OF PRODUCTION.

	July, 1913		Total, barrels	Daily average		
	Produced, barrels	Purchased, barrels		First half of 1913, barrels	1912, barrels	1911, barrels
San Joaquin Valley.						
Coalinga	78,008	628,202	706,210	18,751	16,944	15,158
Kern River	----------	----------	----------	1,357	5,802	5,673
Maricopa	----------	125,630	125,630	3,298	3,938	2,983
Midway-Sunset	518,098	439,596	957,694	32,435	41,696	36,036
Belridge	----------	51,367	51,367	945	408	----------
Lost Hills	49,579	83,220	132,799	2,774	266	----------
Totals	645,685	1,328,015	1,973,700	59,560	69,054	59,850
Coast.						
Santa Maria	----------	6,351	6,351	175	458	1,397
Fullerton	----------	96,643	93,643	3,115	2,660	643
Whittier	----------	23,690	23,690	806	280	460
Coyote	99,550	59,898	159,448	3,639	1,236	----------
Ventura	----------	37,432	37,432	1,203	569	312
Newhall	6,671	----------	6,671	236	265	----------
Totals	106,221	224,014	330,235	9,174	5,468	2,812

STANDARD OIL COMPANY.

Receipts.

	July, 1913, barrels	Total, barrels	Gravity
Coalinga—			
Own property	77,851	77,851	21.5
Purchased.			
Stockholders	2,268		19.6
Coalinga Oil	2,663		34.5
California Oilfields	403,931		20.0
Caribou	35,024		21.7
Home	2,228		34.0
Mohawk	24,607		27.1
Pantheon	4,103		19.2
Record	20,307		21.3
Turner	85,157		21.5
W. K.	39,804		21.5
Aztec	5,467		18.5
		625,589	
Total		703,440	
Maricopa—			
M. & M. and M. J.	17,790		20.0
M. & T.	2,870		21.2
National Pacific	4,480		23.4
Midway Northern	35,315		23.0
Maricopa Northern	4,243		21.7
General Petroleum (J. M. K.)	5,229		17.0
August	1,790		21.2
La Blanc	2,240		18.4
D. L. Peters, Maricopa Union	4,690		21.6
Lakeview, No. 2	25,550		26.0
Panama	5,059		18.2
Ethel D.	5,290		18.8
Total		114,546	
Belridge—			
Purchased.			
Belridge	50,077		25.2
Mannell Minor	1,190		26.9
Total		51,267	
Lost Hills—			
Own property	49,009	49,009	34.8
Purchased.			
Vulcan	37,847		34.5
Universal	45,288		22.5
D. & J.	368		32.7
		83,503	
Total		132,512	
Midway—			
Own property	50,513		23.8
Own property	137,880		20.3
Own property	20,144		23.6
Own property	2,226		20.3
Own property	5,410		24.0
Own property	9,493		23.7
Own property	64,707		19.1
Own property	7,270		19.9
Own property	13,871		23.7
Own property	206,784		27.1
		518,298	

STANDARD OIL COMPANY—Continued.

Receipts.

	July, 1913, barrels	Total, barrels	Gravity
Purchased.			
Midway P. and G.	2,693		18.4
Safe	7,505		13.7
B. H. & C.	2,121		14.2
Hale & McLeod	9,461		21.2
Midway Premier	14,843		22.8
St. Lawrence	12,123		21.6
Canadian Pacific	5,089		24.3
Midway Syndicate	15,140		26.4
United	21,410		21.2
United	1,650		22.6
Mays	8,810		22.5
Mays	43,650		25.5
Eagle Creek	25,287		23.3
Alaska Pioneer	13,105		25.2
Honolulu	85,207		27.5
Olig Crude	5,631		26.1
Mammoth	4,714		20.6
Buick	1,877		25.3
California Midway	2,937		22.3
Stockton Midway	20,678		20.6
Tumbador	19,749		18.6
California Amalgamated	5,485		23.7
Visalia Midway	9,942		19.2
Fairfield	2,650		20.6
Fairfield	1,391		21.6
Midway Royal	3,604		20.0
Kallispel	7,258		19.9
Reward	3,788		18.9
Engineers	9,679		20.3
Manley & McGinn	4,290		18.3
Oakland Midway	5,637		21.4
Edmunds Midway	1,650		20.5
Baltimore	450		25.0
Pacific Crude	20,053		24.0
Boston Pacific	23,448		26.4
Pyramid	1,832		24.4
Pyramid	880		20.2
Pioneer Midway	10,713		22.7
Recovery	2,356		20.7
Pinal-Dome (Gem)	4,112		18.6
		442,898	
Total		961,196	
Santa Maria—			
Purchased.			
New Penn Oil	6,881	6,881	24.0
Fullerton—			
Purchased.			
Birch Oil Company	9,110		22.0
Brea Canyon	26,760		23.0
Fullerton "BC"	58,800		23.0
Fullerton Olinda	1,973		29.5
Total		96,643	
Whittier—			
Purchased.			
Murphy Oil Company	25,150	25,150	20.0

STANDARD OIL COMPANY—Continued.

Receipts.

	July, 1913, barrels	Total, barrels	Gravity
Coyote—			
Own property	99,550	99,550	25.0
Purchased.			
Graham & Loftus	8,017		20.0
Petroleum Company	21,115		23.0
Walker Brand	2,310		18.6
Murphy	27,356		30.0
St. Helens	1,100		19.0
		59,898	
Total		159,448	
Ventura—			
Purchased.			
Montebello	36,510		34.0
Calumet	880		31.0
Total		37,390	
Newhall—			
Own property	728		14.5
Own property	6,076		33.0
Total		6,804	

UNION-AGENCY

This heading includes the Union Oil Company and the Independent Oil Producers Agency.

The Union Oil Company is one of California's oldest oil concerns, having grown from the partnership of Stewart & Hardison, pioneer operators in Ventura County. The company owns a refinery at Avila (Port Harford) and one at Oleum (San Francisco Bay). It has pipe lines in the fields about Los Angeles, Ventura County and Santa Maria, besides several tank steamers. It will be noted that the oil taken by this company is mostly above 18° and totals about one fifth of that handled by the Union-Agency combined. This company is under option to an English concern.

The Independent Oil Producers Agency is a combination formed in 1906 and 1907 of about one hundred and seventy-five companies, located, with few exceptions, in the San Joaquin fields. The bulk of their production is about 15° or 16° Baumé (fuel oil). Their production is handled through a central organization, with the purpose of better protecting themselves in marketing. The agency owns no transporting, refining or retailing plants.

Under contract, running for a term of years, the Union Oil Company agrees to dispose of the agency oil, along with its own, on a commission basis, and to accomplish this the Producers Transportation Company was formed and now operates pipe lines from the San Joaquin fields to Port Harford.

The following figures show details of the Union-Agency production:

UNION-AGENCY, CONTROL OF PRODUCTION.

	By fields. July, 1913			Daily average		
	Union, barrels	Agency, barrels	Total, barrels	Half of 1913,	1912, barrels	1911, barrels
Valley—						
Coalinga	31,383	193,868	225,251	7,735	9,404	8,160
Kern River	----------	135,692	135,692	4,077	3,883	4,703
Maricopa	26,333	66,014	92,347	2,267	1,940	3,059
Midway	188,531	448,444	636,975	15,835	8,940	7,775
McKittrick	----------	96,785	96,785	3,113	3,297	3,421
Lost Hills	12,168	----------	12,168	259	415	----------
Totals	258,415	940,803	1,199,218	33,286	27,879	27,118
Coast—						
Santa Maria	306,187	----------	306,187	8,825	9,313	10,280
Fullerton	221,475	----------	221,475	7,784	6,981	9,003
Salt Lake	7,388	----------	7,388	384	325	516
Whittier	9,200	----------	9,200	298	291	251
Coyote	21,344	----------	21,344	941	49	----------
Ventura	19,862	----------	19,862	611	678	647
Totals	585,456	----------	585,456	18,843	17,637	20,697
Totals for state	843,871	940,803	1,784,674	52,129	45,516	47,755
Half of 1913, average	24,803	27,326	52,129			
1912 average	21,049	24,467	45,516			

UNION OIL COMPANY.

Receipts.

	July, 1913		Gravity
	Barrels	Barrels	
Coalinga—			
Canadian Coalinga	1,811		26.0
Claremont Oil Company	8,778		14.5
Union (Iredell)	33,814		15.0
Total		44,403	
Maricopa—			
J. B. & B. (by cars)	2,978		13.3
Webster (to Producers Transportation Company)	3,464		14.9
Sage (to Producers Transportation Company)	3,754		16.7
International (fuel)	500		15.0
Lakeview Section 25 (to Producers Transportation Company)	3,756		20.0
Lakeview Section 34 (to Producers Transportation Company)	3,036		26.4
		17,488	
Purchased.			
Obispo Oil Company	9,215		25.9
		9,215	
Total		26,703	
Midway—			
Own property	875		25.0
Own property	3,497		24.0
Own property	79,035		27.0
		83,407	
Purchased.			
Section 2 Syndicate	15,471		27.0
Mascot	39,000		14.4
D. L. Peters (Midway 5)	6,354		23.0
Pinal-Dome	11,616		18.6
California Counties	13,730		26.3
Pierpont	18,953		14.1
		105,124	
Total		188,531	
Lost Hills—			
Purchased.			
Dudley & Dudley	12,468		33.6
		12,468	
Santa Maria—			
Own property	779		17.0
Own property	38,951		17.5
Own property	11,099		19.0
Own property	81,262		20.0
Own property	3,502		22.0
Own property	28,287		22.5
Own property	9,251		23.5
Own property	17,022		24.0
Santa Maria Oil and Gas	26,177		20.5
Santa Maria Oil Company	4,051		24.0
		220,381	
Purchased.			
Pacific Oilfields	1,711		19.0
Orcutt Oil Company	8,475		20.0
Brookshire	6,907		22.5
Pinal-Dome Oil Company	22,440		15.0
Pinal-Dome Oil Company	529		16.5
Pinal-Dome Oil Company	17,287		18.0
Pinal-Dome Oil Company	13,933		25.0
Palmer-Union	12,790		13.5
		84,072	
Total		304,453	

UNION OIL COMPANY—Continued.

Receipts.

	July, 1913		Gravity
	Barrels	Barrels	
Fullerton—			
Own property	77,614		18.5
		77,614	
Purchased.			
Columbia Oil Producing Company	35,623		19.5
Columbia (Orange)	42,316		22.0
Olinda Land	9,018		15.0
Birch Oil Company	46,162		22.0
West Coast	7,669		19.0
		140,788	
Total		218,402	
Salt Lake—			
Own property (Garbutt)	6,997		15.0
Purchased.			
Stephens lease	391		18.0
Total		7,388	
Whittier—			
Own property	438		17.5
Purchased.			
Canadian Pacific	9,090		19.0
Total		9,528	
Coyote—			
Own property	24,881		20.0
Purchased.			
Dorsby Oil Company	3,303		20.0
Total		28,184	
Ventura—			
Own property	15,769	15,769	27.0
Purchased.			
Forest City National	218		27.0
Pyramid Oil Company	1,170		17.5
Salt Marsh Canyon	164		25.0
E. E. Henderson	462		27.0
Shell Petroleum	199		24.0
Big Sespe (W. & B.)	724		21.0
South Pacific	441		25.0
Cosmopolitan	307		35.0
Bardsdale Crude	324		24.0
		4,009	
Total		19,778	

ANALYSIS OF AGENCY PRODUCTION, JULY, 1913.

Coalinga Field.

Company	Production, barrels	Gravity
Amity	2,534	15.0
Amy	2,767	14.5
Arizona Petroleum	3,424	13.2
B. & B.	9,599	16.6
British Consolidated	8,518	15.2
Call Oil Company	2,512	18.7
Coalinga Petroleum Company	1,803	13.5
Coalinga North Pole	435	26.0
Coalinga National	----------	14.5
Coalinga Homestake	1,201	13.3
Coalinga Unity	----------	13.0
Coalinga Security	----------	16.2
Coalinga Central	----------	13.0
Confidence Oil Company	1,521	16.6
Creme Petroleum	----------	14.9
De Luxe	500	14.5
Empire	1,175	18.5
Esperanza O. & G.	11,016	16.8
Hawkeye	----------	13.0
Mercantile	5,153	14.8
Nevada Petroleum	75,198	16.0
New San Francisco	1,721	17.0
Ozark	3,602	13.6
Pacific States	940	26.0
Pilot	3,270	13.6
Premier	9,652	15.0
C. M. Hazard (Queen)	1,052	12.5
Republic	----------	18.5
St. Paul Consolidated	6,091	13.0
Seneca	2,151	13.0
Shawmut	5,113	17.0
Silver Tip	5,210	26.0
Strong Oil Company	----------	13.0
S. W. & B.	2,009	16.5
Spinks Crude	5,389	13.2
Traders	19,938	14.5
United Development	3,173	14.5
Ward	6,268	13.5
York Coalinga	1,580	17.0
Marion Oil Company	300	15.0
Total	204,845	

ANALYSIS OF AGENCY PRODUCTION, JULY, 1913—Continued.

Kern River Oil Field.

Company	Production, barrels	Gravity
Acme Development	1,549	12.5
American Crude	3,761	13.6
F. C. Berry	1,574	12.6
Boston Petroleum Company	3,484	13.3
Calloma Oil Company	1,596	13.6
Calloma Extension	5,558	13.3
Del Rey No. 1	4,583	13.1
Del Rey No. 2	1,516	13.1
Eastern Consolidated	----------	13.7
East Puente	5,610	13.5
Eldorado Oil Company	3,146	13.6
Frank Evans (Potomac)	1,647	13.8
Fox & Garrett	3,375	13.0
Homer	4,657	13.0
Illinois Crude	1,868	14.6
Jewell	----------	12.6
Junction	4,017	13.0
Kern Four	8,085	13.9
Knob Hill	10,753	14.9
Loscomb & Bridge	4,934	14.6
Los Angeles-Kern	2,328	12.9
May Oil	4,433	12.8
Mecca Oil Company	5,526	13.9
Mecca No. 2	3,168	13.0
Melwood Petroleum	528	12.9
M. C. Parker	2,282	13.5
M. P., account Gen. Bel	2,149	12.8
Nevada County	6,186	14.3
Ojai Valley Petroleum	975	13.2
Patricia	7,750	13.6
Pricewell	2,429	13.5
Rambler	4,624	13.0
Revenue	----------	13.4
Section 6	1,267	13.8
St. Clair and Jastro	2,853	13.0
Tejon	10,572	13.0
Traffic No. 19	666	13.0
Traffic No. 30	3,190	13.9
Traffic No. 36	500	12.7
Wrenn Oil Company	2,183	14.1
Yellowstone	3,796	13.2
E. A. Clampitt (was Atlanta)	5,227	14.6
Total	144,351	

ANALYSIS OF AGENCY PRODUCTION, JULY, 1913—Continued.

Maricopa and McKittrick.

Company	Production, barrels	Gravity
Maricopa—		
American Oilfields	----------	19.0
McCutchen Brothers	1,700	13.0
Muscatine	5,516	12.2
Maricopa National Petroleum	3,353	21.3
Tannehill	2,837	12.8
United Crude	504	13.7
General Petroleum Company (Essex)	13,102	21.3
Pacific Midway	3,382	22.2
Walter Snook	1,916	12.8
Johnson	----------	15.0
Boston Pacific	1,814	12.9
Miocene	28,487	21.2
Ethel D.	19,887	18.9
Total	82,498	
McKittrick—		
Berry & Keller	26,477	16.0
East Puente	26,336	14.2
Jackson	----------	14.0
Jewett	8,368	14.6
Olig Crude	6,086	15.6
San Francisco and McKittrick	22,819	16.0
Fairfield	4,029	15.2
Temblor Ranch	300	15.4
Dillon	615	15.5
U. S. Oil and M.	60	11.6
Shear Petroleum Company	300	15.5
Mahaska Oil Company	1,545	11.6
Total	96,935	

ANALYSIS OF AGENCY PRODUCTION, JULY, 1913—Continued.

Midway.

Company	Production, barrels	Gravity
Alberta Midway	2,863	13.2
American Oilfields	264,906	17.0
August	----------	----------
Brad	1,105	16.5
Carbo Petroleum	7,907	14.0
Cheney-Stimson	8,970	14.0
Combined	3,574	13.0
Dominion	8,473	15.6
Dunlop	7,243	14.0
Hondo	17,346	15.2
Indian and Colonial	30,489	13.5
Manhattan Midway	----------	----------
Manley & McGinn	10,736	15.0
March	3,834	13.8
Midway Peerless	10,658	15.0
Paraffine	10,566	13.9
T. W. Oil Company	14,328	14.2
H. W. Thomas (Fox)	2,367	14.6
Tamalpais	1,928	13.9
Traders	22,760	13.0
Traffic	600	19.0
Victor	1,203	12.5
W. T. & M.	7,563	13.8
Wilbert	13,339	13.5
Total	452,758	

ASSOCIATED OIL COMPANY.

The Associated Oil Company was organized about 1901, in the early days of the Kern River field, as a consolidation of many small companies who had no means of marketing oil. During the process of providing transporting and retailing facilities, the majority of stock has passed to the Southern Pacific Railway Company. The related holdings falling under the Southern Pacific control and managed in close conjunction with the Associated Oil Company are the Associated Pipe Line Company and the Amalgamated Oil Company. This group of companies has pipe lines from all the fields, except Ventura County, several refineries and tank steamers.

The sources of the oil handled by the Associated and Amalgamated companies are as follows:

ASSOCIATED OIL COMPANY.

Production by Fields.

Field	Total, barrels	July, barrels	Daily average		
			Half of 1913, barrels	1912, barrels	1911, barrels
Coalinga	322,052	50,944	11,466	14,168	16,489
Kern	487,183	245,266	15,772	15,964	19,215
Maricopa	50,406	----------	1,876	2,180	2,528
Midway	212,157	102,609	5,902	4,617	4,279
McKittrick	146,365	124,650	5,651	7,952	9,573
Belridge	117,021	----------	4,071	3,204	----------
Lost Hills	107,255	22,074	3,489	2,710	266
Santa Maria	71,990	19,297	2,433	3,170	2,936
Total	----------	564,840	50,660	53,965	55,316
July average	48,852	18,221			
June average	48,324	16,685			
Half of 1913	50,660	16,876			
1912 average	53,965	17,078			

NOTE.—"Total" shown in second column shows company's production plus oil purchased and the daily averages in last three columns are based on this total.

ASSOCIATED OIL COMPANY.

Receipts.

	July, 1913. barrels	Total. barrels	Gravity
Coalinga—			
Own property	47,129		15.0
Own property	11,974		21.4
		59,103	
Purchased.			
American Petroleum	186,317		18.0
California Oil and Gas	1,702		15.6
Coalinga Eight	3,284		15.8
Coalinga Peerless	12,232		20.2
Good Luck	2,944		18.0
Inca Oil	27,615		13.7
Recovery	971		18.0
Sauer Dough	7,638		21.3
California Oil Fields	27,713		20.0
Wabash	4,104		15.2
		274,520	
Total		333,623	
Kern River—			
Own property	248,532	248,532	14.0
Purchased.			
Calloma Oil Company	574		13.6
Calloma Extension	1,389		13.3
Knob Hill	2,617		14.9
Alma	4,350		14.3
Apollo	7,776		14.2
Bankers	13,550		13.6
Bald Eagle	10,112		13.8
Claremont	10,974		14.9
Enos	2,639		13.8
Four Oil Company	14,650		14.4
Kern River	2,354		13.9
Kern River Oil Fields	70,381		14.8
Peerless	45,689		14.6
Sacramento	4,974		14.0
Soverign	9,265		14.1
Sterling	34,157		14.1
Vesta	7,255		14.0
		242,706	
Total		491,238	
Maricopa—			
Monarch	9,720		13.8
Monarch	14,932		19.6
Fulton (through refiners)	18,452		13.6
Ruby	5,982		13.9
Total		49,086	
Midway—			
Own property	7,456		17.0
Own property	4,502		21.4
Own property	85,028		26.5
Own property	823		24.3
		97,809	
Purchased.			
Section 25	63,578		14.8
Hawaiian	45,922		23.4
Recovery	5,548		20.7
		115,048	
Total		212,857	

ASSOCIATED OIL COMPANY—Continued.

Receipts.

	July, 1913, barrels	Total, barrels	Gravity
McKittrick—			
Own property	132,850	132,850	18.6
Purchased.			
Kern River	5,176		14.5
State Consolidated	15,839		15.6
		21,015	
Total		153,865	
Belridge—			
Purchased.			
Belridge Oil Company	124,021		25.2
Lost Hills—			
Own property	21,280		22.0
Purchased.			
Universal	82,305		22.5
Total		103,585	
Santa Maria—			
Purchased.			
Refiners and Producers	4,591		22.4
Rice Ranch	16,862		29.0
Western Union	24,973		25.5
Western Union (through Refiners and Producers)	9,541		25.5
California Coast	19,297		23.0
Total		75,264	

AMALGAMATED OIL COMPANY.

Control of Production.

District	July, 1913			Daily average		
	Produced, barrels	Purchased, barrels	Total, barrels	Half of 1913, barrels	1912, barrels	1911, barrels
Fullerton	70,621		70,621	2,169	2,677	2,330
Salt Lake	129,890	85,747	215,637	6,303	6,472	6,694
Whittier				77	564	1,037
Coyote	60,454		60,454	2,714	2,353	
Ventura		913	913		11	25
Totals	260,965	86,660	347,625	11,266	12,077	10,086
Half of 1913	8,746	3,567	12,313			
1912 average	7,785	4,292	12,077			

Receipts of Los Angeles Pipe Line.

From—	June, barrels	July, barrels
Fullerton	71,313	70,930
Salt Lake	202,813	215,611
Whittier		
Coyote	60,518	55,347
Ventura		913
Totals	334,644	342,801

Receipts of Amalgamated.

	Produced, barrels	Purchased, barrels	Total, barrels	Gravity,
Salt Lake District—				
Salt Lake	56,877	----------		14.5
Arcturus	33,265	----------		17.0
Amalgamated	14,741	----------		16.5
West Coast	21,838	----------		16.5
American Petroleum	----------	10,168		15.0
La Brea	----------	65,002		12.5
Pacific Light and Power Company	----------	13,720		14.5
Totals	126,721	88,890	215,611	
Fullerton—				
West Coast	70,930	----------	70,930	19.0
Coyote—				
Amalgamated	55,347	----------		22.0
General Petroleum	----------	31,554		19.0
Totals	55,347	31,554	86,901	

KERN TRADING AND OIL COMPANY.

The Kern Trading and Oil Company is a subsidiary of the Southern Pacific Railway Company, operating in the San Joaquin fields upon lands granted by the United States government to the railroad company. The oil is handled largely by the Associated pipe line and furnishes the railroad with fuel.

Sources of Kern Trading and Oil production and receipts (largely royalty) are as follows:

KERN TRADING AND OIL COMPANY.

Control of Production.

District	July, 1913			Daily average		
	Produced, barrels	Purchased, barrels	Total, barrels	Half of 1913, barrels	1912, barrels	1911, barrels
Coalinga	269,141	67,358	336,499	11,245	9,645	7,943
Kern	63,762	----------	63,762	1,939	1,825	1,591
Maricopa	133,414	----------	133,414	4,045	3,566	2,086
Midway	157,349	----------	157,349	4,733	2,632	302
McKittrick	54,286	67,073	121,359	3,187	1,729	1,499
Summerland	350	----------	350	12	12	12
Totals	678,302	134,431	812,733	25,161	19,439	13,433
Half of 1913 average	21,370	3,791	25,161			
1912 average	16,984	2,454	19,438			

Kern Trading and Oil Company Receipts for July, 1913.

	Receipts, barrels	Total, barrels	Gravity
Coalinga—			
Own property	14,244		14.6
Own property	47,510		14.7
Own property	7,241		24.0
Own property	9,598		15.8
Own property	37,022		14.7
Own property	33,014		14.7
Own property	3,297		19.2
Own property	62,555		19.2
Own property	3,363		15.8
Own property	55,050		24.0
		272,894	
Purchased.			
Amity Oil Company	2,534		15.0
Commercial Petroleum	18,955		19.5
Arica	8,113		17.0
Coalinga Pacific	4,193		16.8
Guthrie (Maine State)	4,393		17.5
Pennsylvania Coalinga (Cypress)	4,257		13.8
Section 7	4,253		16.0
Pennsylvania Coalinga	6,946		15.0
W. W. Machen	4,932		18.5
Zier	8,868		13.9
		67,444	
Total	----------	340,338	
McKittrick—			
Purchased.			
Reward Oil Company	69,873		15.0

GENERAL PETROLEUM COMPANY.

The General Petroleum Company was organized about 1911. It owns producing property in the San Joaquin and southern fields, a pipe line from Midway to tide water at Los Angeles, and two topping plants. Control of this company is reported to have recently passed into the hands of an English company.

Production of this company is as follows:

Production by Fields.

Field	July, barrels	Daily average, half of 1913, barrels	Total
Coalinga	9,889	295	9,889
Maricopa	13,102	1,766	50,206
Midway	250,108	8,743	398,279
Lost Hills	35,108	731	35,424
Belridge	21,222	737	21,222
Fullerton	32,814	1,061	32,814
Totals	362,243	13,333	

SANTA FE.

The Atchison, Topeka and Santa Fe Railroad owns oil property, (Petroleum Development Company and Chanslor, Canfield, Midway Oil Company), in the Kern River, Midway and Fullerton fields. The production goes to the locomotives of the road but otherwise the company can not be considered as a marketing concern.

AMALGAMATED OIL COMPANY.

See Associated Oil Company.

THE SHELL COMPANY OF CALIFORNIA.

This company, reported to be related to the Royal Dutch Shell Company and the Shell Transport Company, recently purchased producing property in Coalinga. Tank farms have been built at Coalinga and Midway. A pipe line from Coalinga to San Francisco Bay is under construction.

MISCELLANEOUS.

Miscellaneous sales of oil are made by a few small producers as shown by the following figures for July, 1913.

RUNS AND SHIPMENTS OF MISCELLANEOUS OIL.

	July, 1913, barrels	Gravity
Midway—		
Dunlop (local sale)	280	14.0
American Oil Fields (by cars)	503	distillate
American Oil Fields (by cars)	3,431	14.0
Kern Crown (by cars)	1,800	21.0
South Midway (by cars)	3,000	25.0
Rock (by cars)	6,500	18.3
San Francisco Midway (by cars)	4,000	18.0
Total	19,514	
Santa Maria—		
Palmer-Union (Commercial Brick Company)	560	13.5
Palmer-Union (Pacific Coast Railway)	1,600	13.5
Palmer-Union (St. Helens)	400	13.5
Brooks Oil Company (local)	600	14.0
Oilfields Syndicate of San Francisco (local)	100	14.0
Santa Maria Oilfields of California (J. R. Ott)	12,000	13.0
Total	15,260	
Fullerton—		
Columbia Oil Producing Company—Pico (to Puente)	7,699	23.0
Columbia Oil Producing Company—Olinda (to Puente)	3,300	32.0
Columbia Oil Producing Company—Hill (to Puente)	2,300	30.0
Total	13,299	
Salt Lake—		
A. F. Gilmore (local)	11,550	15.5
Whittier—		
Whittier Crude (to self)	1,120	22.0
Home of Whittier (to self)	2,255	18.5
Colorado (Kellogg)	4,145	18.0
Murphy (Hercules)	796	20.0
Central (Kellogg)	19,495	20.5
Total	27,811	
Coyote—		
Amalgamated (to Kellogg)	8,175	20.0
Ventura—		
Zenith (by cars)	500	17.0
Clampitt Bros. (by cars)	1,200	17.0
D. A. Connell (by cars)	303	16.0
Bardsdale Crude (by cars)	426	24.0
Lapp & Gifford (to self)	400	27.0
Aloha Oil (Harris)	1,260	15.0
Averill & Grinnell (self)	100	----------
Bard Oil and Asphalt Company (Capitol Crude)	2,160	18.0
West Huasna	360	15.0
Capitol Crude (self)	800	20.0
Empire	685	36.0
Emslie (Densmore)	1,800	26.0
Modello (Tarr)	935	28.0
Ojai (Hercules)	1,000	17.0
Petrol (Densmore)	300	37.0
Santa Maria Crude (Hercules)	500	17.0
Sespe Consolidated (Lapp & Gifford)	260	12.0
Sunset (Harris)	125	14.5
Ventura, California	450	23.0
White Star (Densmore)	3,300	34.0
Total	16,864	
Los Angeles—		
Harris Oil Company	13,585	
Lapp & Gifford	620	
Miscellaneous	12,700	
Total	26,905	

RUNS AND SHIPMENTS OF MISCELLANEOUS OIL—Continued.

	July, 1913, barrels	Gravity
Summerland—		
Geo. Baker	1,700	
Sunset	500	
Geo. Appel	250	
Benj. Bennett	250	
Seaside	500	
Duquesne	450	
J. C. Lillis	350	
Total	4,000	

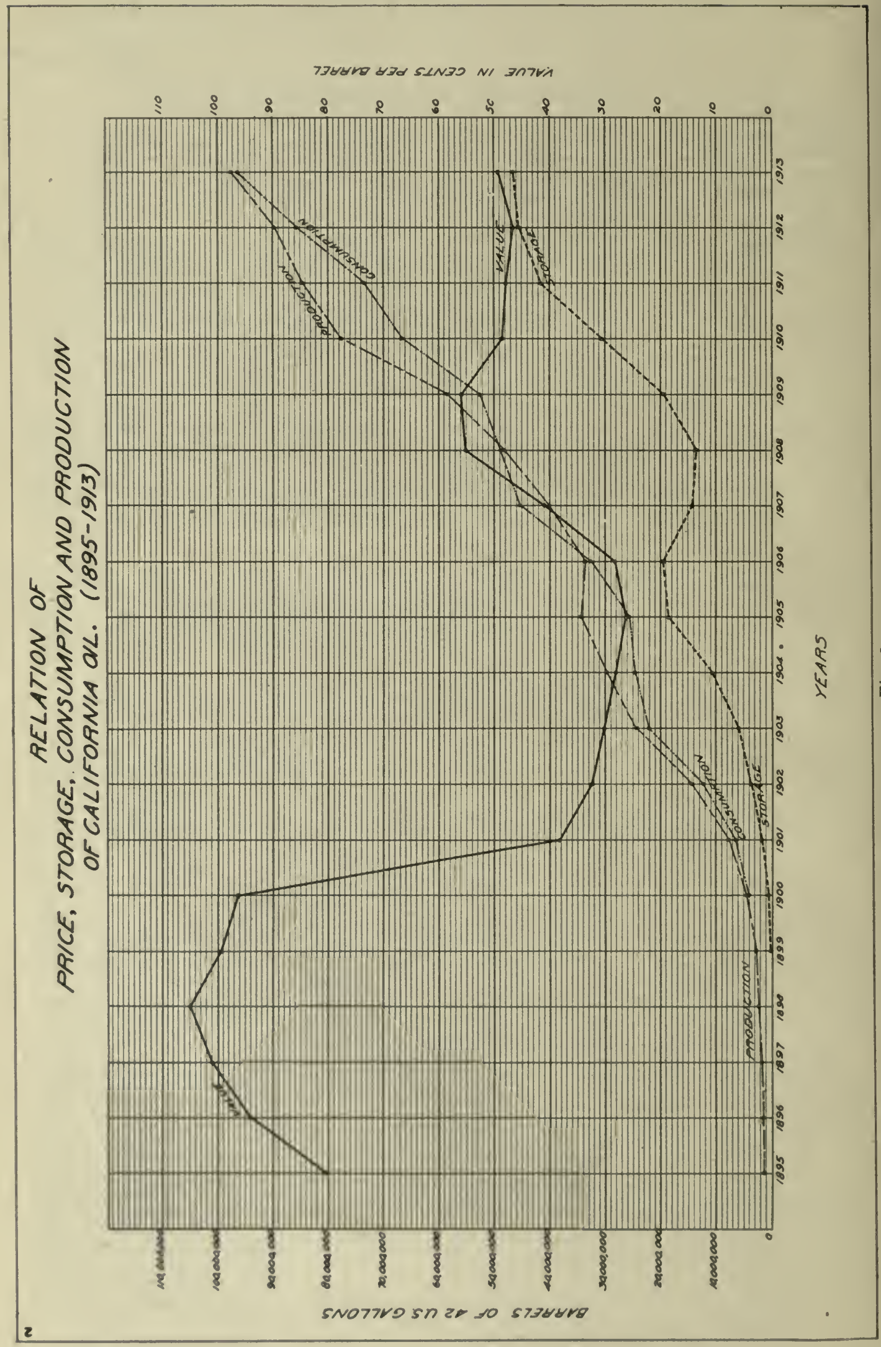
RELATION OF
PRICE, STORAGE, CONSUMPTION AND PRODUCTION
OF CALIFORNIA OIL. (1895-1913)
VALUE IN CENTS PER BARREL
0
10
20
30
40
50
60
70
80
90
100
110
BARRELS OF 42 U.S. GALLONS
0
10,000,000
20,000,000
30,000,000
40,000,000
50,000,000
60,000,000
70,000,000
80,000,000
90,000,000
100,000,000
110,000,000
YEARS
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
VALUE
PRODUCTION
CONSUMPTION
STORAGE
2

Fig. 2.

PRICE OF OIL.

Price fluctuation of crude oil is a question of utmost importance to the industry and greater efforts must be put forward by producers to explain and anticipate them. Many oil operators have carefully and correctly attended to all other business and engineering details and yet have been unsuccessful because the most important feature of all, the price of oil, had not been correctly foreseen.

Any writer attempting to deal with this subject places himself in a precarious position, as many critics are rabid in their views. The cause of this age-old controversy of course centers around the large marketing concerns. One set of extremists holds that the marketing companies are entirely responsible and have the power to manipulate the price to suit their own interest. The other extremists hold that the small operators are entirely responsible, due to their lack of knowledge and unsystematic operations.

Probably the only point upon which the two factions agree is that occasionally each declares that the other has made use of some sort of political influence to gain its ends.

It should not be necessary to state that any person offering a solution of the problem should be able to definitely show his familiarity with the oil industry. Many proposals of legislation, business agreements, incorporations, or other possible means of solution are not backed by any great amount of experience or investigation.

Probably one of the chief reasons, in California, why the price of oil falls below the cost of production is that too many people of comparatively small means enter the business of producing without adequate information. At times when production rapidly increases there is a rush to sell before the price falls and of course such a rush accelerates the fall of price. Operators with small means are frequently in debt and can not afford to suspend operations as long as oil sells above the bare cost of production.

Such an explanation might appear to throw all the blame upon the small producers, but this can not be maintained until the large marketing companies have shown that they earnestly try to educate producers by furnishing accurate accounts of the rate of production, consumption and storage. Such efforts are necessary in order to dispose of charges that the marketing companies stimulate periods of overproduction.

As in most controversies, both sides must be willing to present and thoroughly consider facts and above all give the other fellow credit for being reasonably honest. The Standard Oil Company, in its bulletin of June, 1914, presented an article which is worthy of due consideration and is here reproduced. Following the quotation are some comments, wherein the writer sets forth reasons for not concurring with all their conclusions.

The accompanying diagram (Fig. 2) is similar to the one published by the Standard Oil Company but uses State Mining Bureau figures in all cases except that of storage. Storage figures are those presented by the Standard Oil Company. The Standard's figures of prices since 1907 are considerably lower than those of the State Mining Bureau.

As there is no explanation of method by which the storage figure is obtained, it may also be subject to some question. Such a view is particularly strengthened by the company's statement in the bulletin of July, 1914, where a change of 1,047,162 barrels in the storage figure is noted. Of course the diagram for years earlier than 1905 has little or no value in the discussion, as the storage is only estimated.

"The storage and shipments from 1900 to 1905 are estimated. The shipments for the entire period represent pipe line shipments from the field, and stocks include only pipe line and field stocks.

For the convenience of the reader, the production, shipments, storage and value as expressed by the curves are shown in the chart in tabulated form. This chart was prepared to show the constant relation between prices and oil supply and demand and to answer the statement that is not infrequently made that prices paid for crude oil are largely the result of manipulation. Bearing in mind that the storage curve shows directly the relation between oil supply and demand, that is, as this curve goes up it indicates an oversupply and as it comes down a lack of sufficient current production to fill the demand, its influence on the prices is plainly shown.

In 1901 there was a marked falling off in prices due to the development of the Kern River and McKittrick fields, which that year yielded 3,700,000 barrels of the total of 7,700,000 barrels produced by the state. There was little market for this oil and it sold for as low as 10 cents per barrel; one producer holding a large contract for railroad delivery, buying oil at 13 cents per barrel, f. o. b. cars in the Kern River fields and delivering direct to the railroad at 70 cents per barrel.

From 1901 to 1906 there was a constant oversupply and the average prices consistently dropped. From 1906 to 1909 storage was reduced, the reduction reflecting an increased demand, and values moved up correspondingly.

Nineteen hundred and ten was a gusher period in the Midway district, and storage increased rapidly, accompanied by decreased prices. This condition continued until 1912, when the demand had substantially approached the supply and the prices again started on an upward trend.

The chart clearly shows that as storage, i. e., supply, increases, prices decline, and as storage decreases, prices advance.

Since the chart was prepared, there has been a decline in the value of light crude oils, although the storage of both heavy and light oil shows but little increase since January, 1914, to date. This condition is brought about by the large overproduction of refinable crude and is accounted for by the following facts:

From December 31, 1911, the production of oils under 20° gravity (fuel oils) and over 20° gravity (refinable oils), for each six months' period to December 31, 1913, shows the following:

Six months ending	Barrels (42 gallons)		
	Under 20°	Over 20°	Total
December 31, 1911	28,052,191	15,325,631	43,377,822
June 30, 1912	26,437,746	17,223,996	43,697,742
December 31, 1912	25,500,954	20,875,743	46,376,697
June 30, 1913	25,070,035	22,151,801	47,221,836
December 31, 1913	23,602,839	27,042,509	50,645,348

> It will be seen that from the end of 1911 to the end of 1913, the fuel oil for a six months' period declined 4,450,000 barrels, while the production of light refinable crudes increased 11,700,000 barrels. It may be said further that the average gravity of the light crudes two years ago was but little higher than 21° gravity, while the gravity is now above 25°. The figures here offered should suffice to show that the economic law of supply and demand is the certain and immutable factor in the regulation of prices."

The statement that prices decline as storage increases, is only true in a very broad, general way, and under close examination can scarcely be supported. Some contradictory facts are as follows: For the last four years, since 1910, there has been a nearly constant average price notwithstanding the fact that storage has steadily increased. Furthermore, at several dates, 1905 to 1906, 1908 to 1909, and 1912 to 1913, we observe both storage and price advancing.

One of the factors which enters into the failure to support the statement may be that stocks should include all oil stored on the coast rather than only that in the pipe lines and fields.

Storage increase alone, does not indicate production beyond demand. Storage is necessary in order to insure the filling of demand. In other words, with a consumption of nearly a hundred million barrels we require more storage than when consumption was ten million barrels. The relation between consumption and storage should be expected to give some idea of price, but in 1904 and again in 1909 there was only about four and one half months' supply, and in one case the price was only 28 cents while in the other it was 56 cents. In 1906 and again in 1910 there was about seven months' supply ahead but in the first case the price was only 28 cents, and in the second it was 48 cents.

Even the rate of increase in storage seems to have little or no effect on price. There was a rapid increase of storage from 1909 to 1910 with a marked fall in price, but the same rapid rate of increase in storage continued to 1911 and yet the price declined but little.

It must not be understood that our argument against the statement as to relation between storage and price is also an argument that prices are the result of manipulation. The two propositions are entirely separate and distinct.

Some general principles underlying and governing prices may be worth mentioning. There are certain limits between which prices must always be confined.

The minimum average price is the actual operating cost, or in other words, oil can not sell, in general for any great length of time, for less money than the producer is regularly spending. Of course some leases and contracts would temporarily cause such losses, but in general the principle will prevail. This minimum cost of production is the readily *apparent* cost and does not consider interest, or return of original investment, which enter into the *real* cost. At present the minimum cost is from 18 cents to 23 cents for most of the oil going on the market, as indicated by figures on page 10, which include no fixed charges.

The maximum price at which oil can sell is not so easily determined as there are many influences bearing upon it. In general, fuel oil can not sell for a greater price than that at which the consumer can profit by turning to some other source of power, such as coal, electricity or wood. An instance, merely for an illustration, as the figures may not be exact, is that the maximum cost at San Francisco could not be greater than that of coal which has usually sold wholesale for from $6.00 to $8.00 per ton, but has been estimated as possible at $3.50 (Bulletin 442, p. 92, U. S. Geol. Survey). Tests have shown three and one half barrels of oil to be equal in heating value to a ton of coal. Therefore, the maximum price of fuel oil at San Francisco should be about $1.00, or possibly $2.00, depending on the price of coal. As a matter of fact it has usually sold at from 60 cents to 70 cents. At such prices for oil fuel, delivered, electric power, generated by large steam units favorably located with respect to water supply, is cheaper than that generated by water power when transmission distance is greater than one hundred and fifty miles. (A. H. Babcock, Transactions American Institute of Electrical Engineers, Vol. 29, p. 693.)

There are no facts in the hands of the public showing to what extent California oil has been competing with oils from other regions. If such competition is keen it may upset local statistics as to supply and demand.

The complexity of the subject will be recognized when it is considered that the rapid enlargement of consumption has taken place by spreading the product over new territory and probably cutting the retail price in order to be able to dispose of the oil in competition with other fuels. It is quite possible that some deliveries are necessarily made at so low a price that a slight rise in the price at the wells would necessitate the discontinuing of such sales, and a contraction of the consuming territory. Such a contraction would possibly increase the storage and under normal competitive conditions decrease the retail price nearer to the wells.

Another factor which further complicates the question is the fact that considerable of the oil is refinable and more valuable than fuel oil. The relative amounts of fuel and refinable oil vary from time to time, as shown by the above quoted figures on oil above and below 20° Baume. This factor alone probably so interferes with the value figures, shown on the diagram, as to conceal the possible relation between storage and value.

The article quoted from the Standard Oil bulletin does not show who is responsible for the "large overproduction of refinable crude." This would of course have to be brought out clearly in order to give a complete understanding of the subject.

Other factors affecting the result are: changes in cost of storage reservoirs from simple earth constructed for less than 10 cents per barrel, to steel tanks costing over 25 cents per barrel; changes in cost of transportation by cars or by pipe lines, and changes in methods of selling by producers. Probably no one can definitely state all the causes of fluctuation.

Viewed from the side of the producers, less than one third of whom are paying dividends, or from the point of relative values of fuels, it must be concluded that the price of oil is now below normal and has been for four years. This condition will continue as long as operators continue to drill unnecessary wells and force their product on the market.

Believing the subject of the price of oil to be very important these pages have been rewritten several times and submitted to various persons for criticism. The critics were all well informed and held varying personal views. Finally a letter was addressed to officials of the eight marketing or producing companies listed on pages 30–45. The letter being self-explanatory is as follows:

OCTOBER 14, 1914.

DEAR SIR: The purpose of this letter is to suggest some concerted action in the gathering of oil statistics. Improvement can be made in both economy and accuracy.

A copy of this letter is being addressed to (a list of the seven officials besides the one directly addressed was here given).

As some 36 per cent of the proved oil land in California is not owned by any of the above concerns and as that land yields nearly 45 per cent of the total oil production, this bureau may well be considered as representing such holdings and the general public.

There is a duplication of expense in the present methods of gathering statistics, which you should be interested in avoiding.

Statistics published by an interested party are apt to be accepted with reluctance by the public.

Until the public is thoroughly informed and educated as to how oil is disposed of we may expect agitation by misinformed persons. Such agitation is apt to benefit nobody.

In preparing the manuscript of a bulletin on the "Oil Industry of California," to be published by this bureau, I made the following statement:

> "At present there are at least three private concerns in California collecting statistics upon the production, storage and transportation of oil. Several public institutions also collect some figures. The figures collected by public institutions are, of course, valuable and in some cases probably more accurate than private figures, especially as to prices. However, they fall far short of serving their full purpose, owing to the difficulty and delay in collecting figures and the infrequency of publication. The private concerns who collect statistics are engaged in marketing oil, and each has a man in every important field. His business is to keep thoroughly informed as to development, production, storage and shipment at every property in his territory. Not later than the tenth of each month these marketers have a complete report showing the condition of every oil company during the preceding month. These marketers themselves produce about one third of the total oil output and control practically all that goes on the market. In order to have correct figures on production it is necessary for each of these marketers to exchange with the others a complete list of its monthly purchases. This is not necessarily done with the consent or even knowledge of head officials, but the prompt collection of correct

> figures would otherwise be a physical impossibility. Now bearing in mind this exchange system and that overproduction and low prices result from lack of official information on the part of many producers, it is interesting to note the attitude of the marketers toward a public institution, such as the State Mining Bureau, when detailed production figures are requested. We are informed that the figures are *confidential* between the producer and marketer."

It is not the purpose of this letter to discuss the correctness of the above statement.

Some critics suggest that the publication of such a statement might do more harm than good, break up the present system, and not serve our aim of improving it. Therefore, I will be pleased to have suggestions looking towards a united effort of the marketing companies and the State Mining Bureau. I would suggest that each marketing company make a clearing house of this bureau by sending promptly each month a report for each field in which it operates. It should be possible to account for the several grades of oil, show the amounts purchased, produced, and in storage besides the usual well reports for each grade of oil. The regular gaugers could gather these figures without trouble as each company would be reporting only for its own property and those from which oil was being purchased. Estimates could be made of the small amount of oil not thus accounted for. Such estimates to be mutually arranged for in order to give the best results.

For your information I would say that our present system involves the annual mailing of one of the enclosed blanks to each oil company. That we have the confidence of the producers is shown by the fact that last year we had reports from 97 per cent of the producing companies. However, this method only accounted for about 75 per cent of the total oil, as a few of the very large producers failed to report. Our system would, of course, be continued as a check upon other results. The principal fault with our system is that it works too slowly to be of the greatest benefit to the industry.

May I ask that you give this matter due consideration and consult with some of the other gentlemen mentioned. Suggestions will be welcomed and I shall be glad to meet with you and discuss the matter further.

Thanking you for an early reply, I am

Respectfully yours,

R. P. McLaughlin,
Chief of Petroleum Department.

The above mentioned blank form is as follows:

Note.—A prompt reply is desired whether property is producing or not.

PETROLEUM.

California State Mining Bureau,
Ferry Building, San Francisco, California.

Statistics for the Year 1913.

Dear Sir: The purpose of the State Mining Bureau is to advance the interests of the mineral industry of the state in all possible ways. According to chapter 679, statutes of 1913, the State Mineralogist is required to collect data, annually, and publish the same in proper form, showing the amount and value of the minerals produced in California. It is with a view to compliance with this law, that you are earnestly asked to cooperate with this department by answering as promptly as possible the several questions below. *Names of individual mines or properties will not be mentioned in the report*, the figures you send will be considered as strictly confidential, will not be shown to any one, and will be used in the totals by counties only; *therefore no private business is made public.*

Please fill out this blank at once and return in enclosed prepaid envelope as promptly as possible.

Yours respectfully,

F. McN. HAMILTON,
State Mineralogist.

Barrels petroleum produced, *under* 18° Baume ____________ Value $____________
Barrels petroleum produced, *over* 18° Baume ____________ Value $____________
Total number barrels produced ____________ Value $____________
Barrels petroleum used in field as fuel, etc. ____________
Barrels petroleum, if any, paid as royalty ____________
Number of producing wells, January 1, 1914 ____________
Number wells drilled during 1913 ____________
Number wells abandoned during 1913 ____________
Cubic feet natural gas used or sold (approximately) ____________
Value of natural gas used or sold during year, $ ____________
Number of wells producing gas only ____________
Number of wells producing oil and gas ____________
Number of wells pumped by gas engine ____________
Number of boilers fired by gas ____________

Note.—The State Mining Bureau is interested in the matter of danger to oil wells by water. A statement as to your own difficulty and remedy used, and any suggestion you may give on the subject will be of assistance.

Remarks: ____________

Signature ____________

The value of public good will, which can only be based upon knowledge of the facts, will eventually cause the adoption of some such plan, but it is very interesting to note that four of the concerns, out of the eight addressed, had not the courtesy or interest to acknowledge receipt of the letter. The plan is being pursued by the State Mining Bureau as these pages go to press.

RECORDED PRICES FOR VARIOUS GRADES OF OIL.

Considerable search revealed no long continued record of prices paid for the various grades of crude oil. The following quotations published by the Standard Oil Company will give some idea of the relative values.

Midway-Sunset district	November and December, 1913, per barrel	January to May, 1914, per barrel	June, 1914, per barrel	July, 1914, per barrel	August and September, 1914, per barrel
14° to and including 20.9° gravity	----------	$0.40	$0.40	$0.40	$0.40
18° to and including 20.9° gravity	$0.35	----------	----------	----------	----------
21° to and including 23.9° gravity	.50	.50	.45	.42½	.42½
24° to and including 26.9° gravity	.55	.55	.50	.45	----------
27° to and including 28.9° gravity	.60	.60	.55	.50	.45
29° to and including 30.9° gravity	.70	.70	.65	.60	.55
31° gravity and lighter	.75	.75	.70	.65	.60

Kern River Field, January, 1914, to September, 1914, Kern River Oils, minimum 14° gravity, 40 cents per barrel.

Coalinga Field	November and December, 1913, per barrel	January, February and March, 1914, per barrel	April and May, 1914, per barrel	June, 1914, per barrel	July, 1914, per barrel	August and September, 1914, per barrel
14° to and including 20.9° gravity	----------	----------	$0.40	$0.40	$0.40	$0.40
18° to and including 20.9° gravity	$0.35	$0.40	----------	----------	----------	----------
21° to and including 23.9° gravity	.50	.50	.50	.45	.42½	.42½
24° to and including 26.9° gravity	.55	.55	.55	.50	.45	----------
27° to and including 28.9° gravity	.60	.60	.60	.55	.50	.45
29° to and including 30.9° gravity	.70	.70	.70	.65	.60	.55
31° to and including 32.9° gravity	.75	.75	.75	.70	.65	----------
31° gravity and lighter	----------	----------	----------	----------	----------	.60
33° to and including 34.9° gravity	.80	.80	.80	.75	.70	----------
35° gravity and lighter	.85	.85	.85	.80	.75	----------

Lost Hills and Belridge region	November 1913, to May, 1914, inclusive, per barrel	June, 1914, per barrel	July, 1914, per barrel	August and September, 1914, per barrel
14° to and including 20.9° gravity	----------	----------	----------	$0.40
21° to and including 23.9° gravity	$0.50	$0.45	$0.42½	.42½
24° to and including 26.9° gravity	.55	.50	.45	----------
27° to and including 28.9° gravity	.60	.55	.50	.45
29° to and including 30.9° gravity	.70	.65	.60	.55
31° to and including 32.9° gravity	.75	.70	.65	----------
31° gravity and lighter	----------	----------	----------	.60
33° to and including 34.9° gravity	.80	.75	.70	----------
35° gravity and lighter	.85	.80	.75	----------

Ventura County	November 1913, to May, 1914, inclusive, per barrel	June, 1914, per barrel	July, 1914, per barrel	August and September, 1914, per barrel
21° to and including 24.9° gravity	----------	----------	----------	$0.50
22° to and including 24.9° gravity	$0.70	$0.65	$0.55	----------
25° to and including 27.9° gravity	.80	.75	.65	.60
28° to and including 29.9° gravity	.90	.85	.75	.70
30° to and including 30.9° gravity	.95	.90	.80	----------
31° to and including 31.9° gravity	1.00	.95	.85	.80
32° to and including 32.9° gravity	1.05	1.00	.90	----------
33° gravity and lighter	1.10	1.05	.95	.85

Whittier-Fullerton district	November and December, 1913, per barrel	January to May, 1914, per barrel	June, 1914, per barrel	July, 1914, per barrel	August and September, 1914, per barrel
18° to and including 21.9° gravity	$0.60	$0.55	$0.50	$0.45	$0.42½
21° to and including 24.9° gravity	----------	----------	----------	----------	.45
22° to and including 24.9° gravity	.65	.60	.55	.50	----------
25° to and including 27.9° gravity	.75	.70	.65	.60	.55
28° gravity and lighter	.85	.80	.75	.70	----------
28° to and including 30.9° gravity	----------	----------	----------	----------	.65
31° gravity and lighter	----------	----------	----------	----------	.70

CHAPTER II.

PRODUCTIVE CAPACITY OF OIL LANDS.

Any reasonable venture in the oil business requires some notion as to the amount of oil to be taken from the ground. The question can never be definitely answered owing to the migratory nature of the substance in question as well as to the lack of information on the subject.

A common method of estimation has been based upon the thickness of sand in the property, assuming that 10 per cent of the volume is filled with oil. This method has much to commend it from a theoretical standpoint and in fact appears most logical. However, it lacks proof from a practical view of California conditions, and unless further demonstrated can be of little use. A similar method if applied in estimating the metallic content of a vein of ore would be based upon the measured width of vein and a theoretical assay value, which, of course, reduces the proposition to an absurdity. The view taken by the author is that no rule is justified unless supported by a mass of evidence in the shape of records of past performances of California oil properties, and the attempt has been made to present in this publication as much evidence as possible.

If one still chooses to consider that thickness of sand is the most important factor it will be very well to note that the Kern River field, with very thick undisturbed sands (about 325 feet in the center of the field) has produced not quite 26,000 barrels per acre, or about 1 per cent impregnation, and that the future yield does not promise a very great addition to the figure.* The other fields, with higher yields per acre, are either folded or faulted so that thickness of sand is indeterminate.

Our form of presenting evidence of productiveness is by diagrams and the explanation of one of them will bring out the very valuable features which might otherwise escape notice.

Taking for example the diagram marked "Group B, Coalinga Field," (p. 168) which presents the actual history of a group of wells for six years. It will be noticed that there are three separate and distinct irregular lines upon the drawing. The left hand margin shows the three scales used in drawing the separate lines of the diagram. At the bottom is shown the time scale, divided by vertical lines into periods of three months. Total daily production, as shown by the diagram, is an accurate figure of the average amount of oil produced per day as shown by the total monthly shipments. The number of wells producing is fairly accurate, being taken from monthly field reports. Such reports are subject to some slight error due to the fact that idleness of a single well for a few hours, or days, is seldom noted. Daily production per well is derived from the other two figures, the total daily production divided by the number of wells producing.

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*See page 14.

As an illustration of the three scales, note the vertical line marked "5" which shows that during that month thirty wells produced a daily total of 2,325 barrels or an average of about 78 barrels each.

As a whole the curve shows that at the beginning of the record two wells were producing, and that others were drilled during the next three and a half years until thirty-six were completed, which, with the exception of two or three, have since continued to produce. During the first two years the total daily production rose from 100 barrels to 2,500, was maintained for two years, and has since declined to 1,200 barrels. During the first year, when from two to ten wells were producing, the average daily production per well was variable, probably due to unsettled conditions at the new wells. This is in a general way the history of an ordinary oil property.

The most striking and useful results are shown on the line for daily production per well. It will be noted that for the last four and a half years the average daily yield per well has gradually decreased from about 100 barrels to 40 barrels. The real usefulness of such a diagram on any particular property is that prediction of future production is not so hazardous as might otherwise appear. Extension of the daily well production line gives some reasonable idea of what the production may be at a future date of two or three years.

Upon nearly all the diagrams the daily well production line appears as a straight line, rather than a curve, as has been frequently assumed. The first few wells drilled on a property are usually the largest producers and subsequent wells "come in" at about the rate of those already producing.

UNDERGROUND MOVEMENT OF OIL.

There are too many unknown factors, such as degree of saturation and gas pressure within the oil sands, to allow close calculations upon the underground movement of oil. The behavior of water in underground reservoirs, during short periods of time where there is no added supply from other sources, is possibly similar to that of oil and is worthy of consideration. The following drawing illustrates conditions that have been actually observed in pumping wells.

In the case of a water well perforated in about one hundred feet of gravel the water level has been reduced, along a curved line, for a distance of five miles from the well. This was shown by observations at neighboring idle wells.

The flow would probably be slower in an oil well and the influence would not extend so far away from the well, due to the smaller openings in sand, as compared with gravel, and also due to the greater viscosity of oil. However, the following diagrams may possibly illustrate the action of oil (after the initial gas pressure is exhausted), as wells are drilled one after the other with continually lessening initial production. The probability of interference by such action is one reason why curves of single wells would probably be of less economic value than curves by groups of wells, and furthermore data on single wells is frequently not recorded.

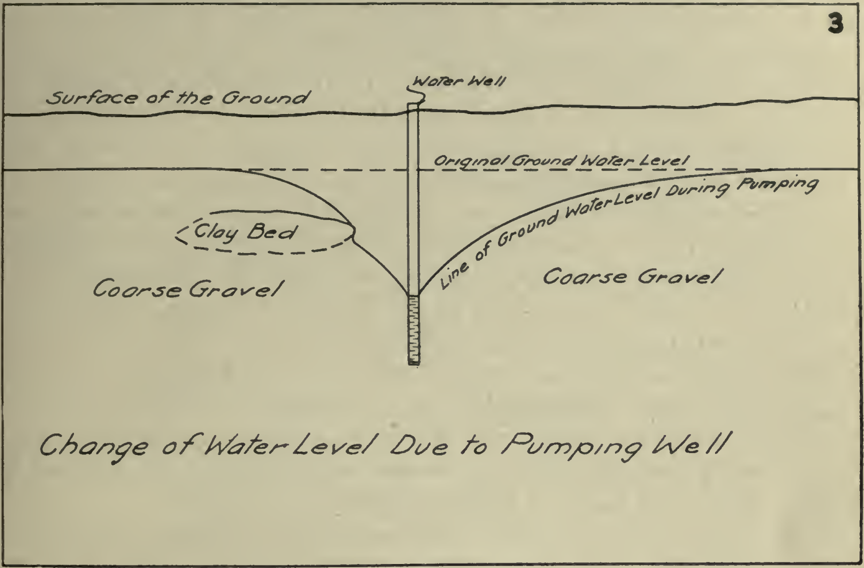

3
Water Well
Surface of the Ground
Original Ground Water Level
Line of Ground Water Level During Pumping
Clay Bed
Coarse Gravel
Coarse Gravel
Change of Water Level Due to Pumping Well

Fig. 3.

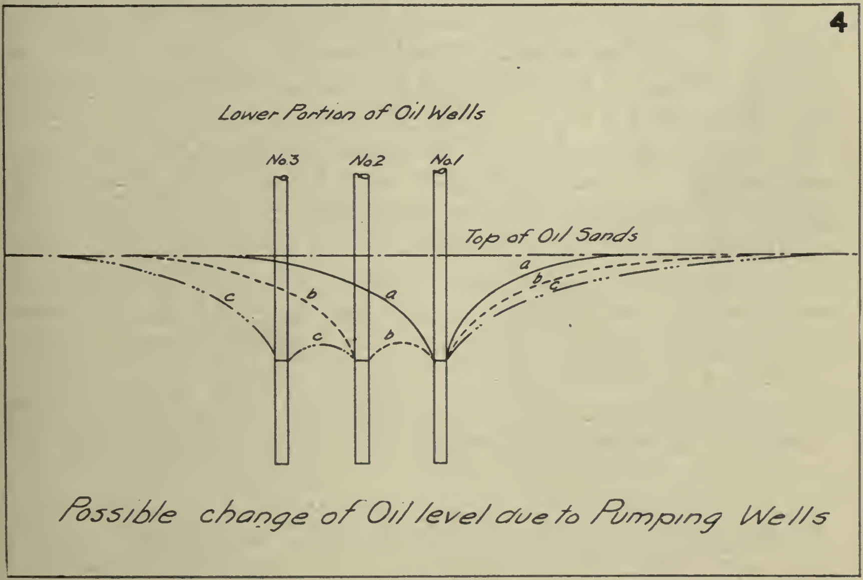

4
Lower Portion of Oil Wells
No.3
No.2
No.1
Top of Oil Sands
a
b
c
a
b
c
b
c
b
Possible change of Oil level due to Pumping Wells

Fig. 4.

The subject is of importance in establishing the most economic spacing of wells and should be experimented on and results recorded systematically.

EVAPORATION LOSS OF OIL.

Loss of oil by evaporation during the time it travels from the well to the consumer has been an unknown quantity. With a view of determining something definite about the loss, a series of tests was outlined, at the suggestion of Mr. H. L. Haehl. The writer is especially indebted to Messrs. H. G. Anderson, H. W. Bell, A. T. Beazley and R. S. Haseltine, of Coalinga, and Mr. Wm. Walker, of Taft, as it was only with their hearty cooperation that the tests were carried out.

It was not expected that the tests would develop anything particularly wonderful, but they have fulfilled our desire of bringing out some definite facts which will serve at least as a basis for future work and estimates. Possibly the results may call attention to some losses that can be avoided without undue expense.

The apparatus used was designed to require the minimum of attention and expense. Specifications were as follows:

Pan of No. 24 galvanized iron, 30 inches by $29\frac{7}{16}$ inches and 6 inches deep (inside measurements). A pointed wire $\frac{1}{8}$ inch in diameter and 5 inches long to be fastened perpendicularly to the bottom of the pan, at its center. Cup to measure additions of oil, $1\frac{1}{2}$ inches in diameter and 1 inch deep (500 cupsful make 1 inch in pan). Roof made of 1 inch pine boards, 32 inches long, ends projecting 1 inch over the gable pieces. Gable piece with 32 inch span, $7\frac{1}{2}$ inch height at the center and $\frac{1}{2}$ inch height at each end. When placed on the pan, therefore, the roof left an opening of about $\frac{1}{2}$ inch along the eaves. Another condition for testing effects of ventilation was to raise the roof $4\frac{1}{2}$ inches above the pan by placing boards 4 inches high and 2 inches thick under each gable piece.

The instructions for the test were as follows: Set pan on level ground where sun shines all day. Have no earth around sides of pan. Fill pan with oil until point of upright wire is level with the surface. Have several extra gallons of exactly the same oil in a storage can which shall be closed to prevent evaporation. Read the thermometer (hanging in sun beside pan) twice daily, at 5.00 a. m. and 2.00 p. m. (minimum and maximum). Record temperatures on blank. Use cup to replace oil that has evaporated from pan. At the warmest part of day add oil from storage can. Record the number of cups added, and date. It may not be necessary to add oil every day but do not allow the surface of oil to fall more than $\frac{1}{8}$ inch below point of wire. Carry a test at least one month for each of the three positions of roof.

(1) With no roof.
(2) With roof $\frac{1}{2}$ inch above pan.
(3) With roof $4\frac{1}{2}$ inches above pan.

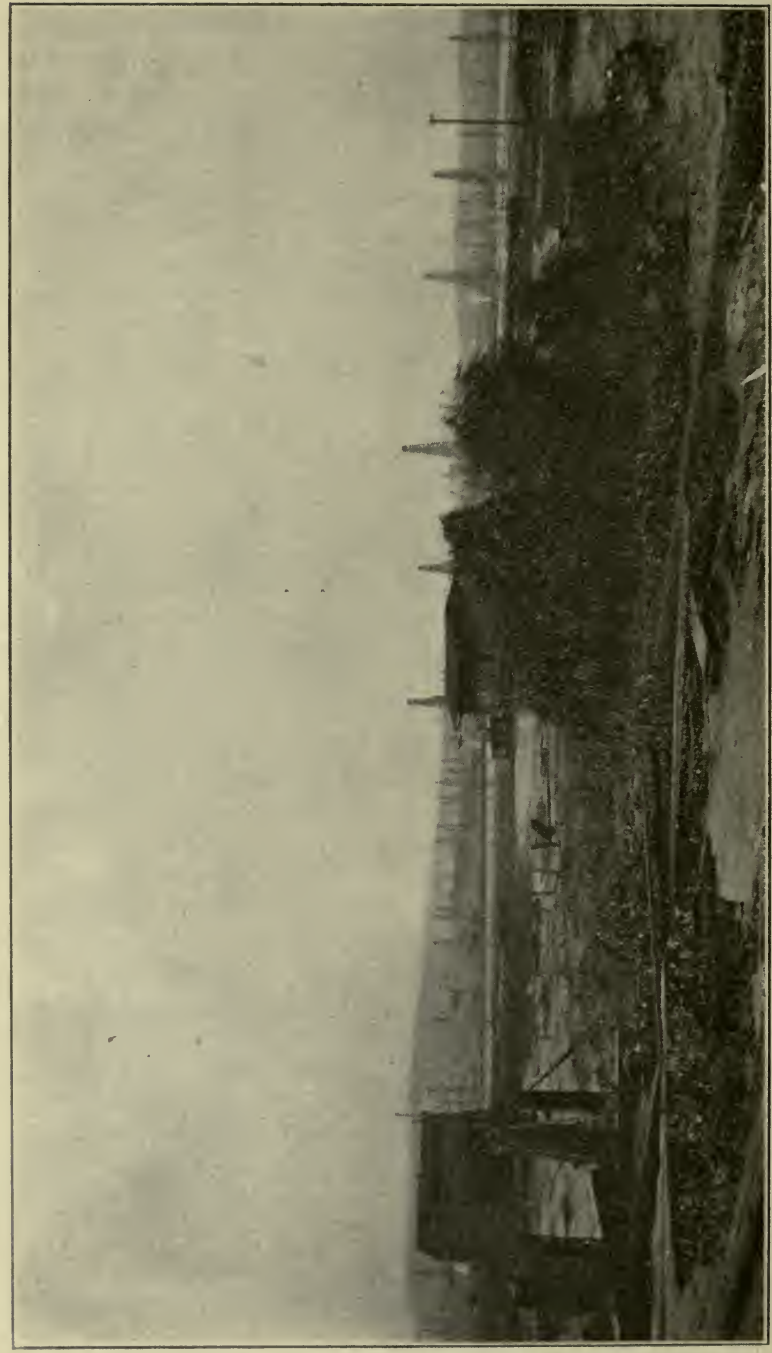
The records of observations are here repeated in full:

Test With No Roof.

No. 1. May, 1914.

Field, Coalinga, West Side. Elevation above sea level, 860 feet.
Test made at property of British Consolidated Oil Corporation, Ltd.
Name of observer, R. S. Haseltine.
Gravity of oil at beginning of test, 12.8° to 12.9°.
Gravity of oil in pan at end of test, top of pan 12.75°, bottom 12.5°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
May 1st	Pan filled	85°	
	53°	85	
	52	86	
	48	86	
	55	87	
	50	92	
	48	85	
	52	80	
	53	72	
May 10th	50	84	48
	53	85	
	57	98	
	61	93	
	53	84	
	50	84	
	49	85	
	51	89	
	57	90	
May 19th	59	99	40
	60	91	
	61	89	
	51	78	
	50	69	
	57	71	
	57	68	
	53	84	
	57	90	
	55	92	
	62	100	
May 30th	66	107	43
Average	55°	86°	
Mean, 70°.			
Total cups	------------	------------	131



LAKEVIEW NUMBER TWO WELL.

Last stage of a gusher well before it stops flowing. Photograph by W. W Thayer.

Test With No Roof.

No. 2. August, 1914.

Field, Coalinga. Elevation above sea level, 802 feet.
Test made at property of The American Petroleum Company.
Name of observer, T. J. Crumpton.
Gravity of oil at beginning of test, 14.7°.
Gravity of oil in pan at end of test, 14.0°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
August 1st	71°	106°	
	73	102	6
	55	94	10
	63	102	15
	71	110	20
	74	106	32
	74	104	16
	64	100	14
	64	98	24
	66	100	30
	69	103	30
	73	106	25
	71	106	20
	73	104	10
August 15th	74	108	16
	75	110	12
	73	104	14
	62	94	22
	55	90	44
	52	92	34
	62	98	19
	65	104	14
	66	100	14
	63	104	10
	65	100	11
	59	94	8
	66	94	10
	59	94	4
	65	96	3
	59	94	3
August 31st	55	90	4
Average	65°	100°	
Mean, 82°.			
Total cups			494

Test With No Roof.

No. 3. May, 1914.

Field, Midway (Taft, Cal.). Elevation above sea level, 1,010 feet.
Test made at property of General Petroleum Company.
Name of observer, I. W. Martin.
Gravity of oil at beginning of test, 22.7°.
Gravity of oil in pan at end of test, 17.0°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
May 1st	50°	72°	116
	48	84	98
	55	95	77
	52	88	56
	58	91	40
	58	95	30
	62	86	29
	56	80	24
	58	74	20
	56	81	21
	55	88	4
	60	93	14
	62	96	10
	55	85	14
May 15th	58	84	19
	53	84	17
	54	88	7
	58	94	13
	61	96	8
	63	93	16
	66	96	15
	55	83	20
	55	81	14
	59	71	12
	59	71	10
	60	84	9
	58	93	8
	60	91	12
	55	92	10
	67	110	4
May 31st	72	109	16
Average	58°	88°	
Mean, 73°.			
Total cups			763

Test With No Roof.

No. 4. May-June, 1914.

Field, Coalinga. Elevation above sea level, 1,012.25 feet.
Test made at property of California Oilfields, Limited.
Name of observer, Wm. Dron.
Gravity of oil at beginning of test, 22.8°.
Gravity of oil in pan at end of test, 18.7°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
May 20th	60°	92°	
	58	88	
	59	91	115
	50	89	
	51	76	58
	51	76	
	51	84	
	58	85	22
	60	99	18
	60	100	
	58	102	
May 31st	59	104	35
June 1st	59	115	45
	62	92	
	56	92	
	52	90	
	50	88.5	40
	52	84	
	50	90	
	51	91	
	51	98	
	54	102	
	54	102	
	50	106	40
	54	110	
	61	118	
June 15th	62	119	
	71	110	
	72	122	
	70	118	
June 19th	62	98	45
Average	57°	98°	
Mean, 77°.			
Total cups			418

Test With No Roof.

No. 5. May, 1914.

Field, Coalinga (West Side). Elevation above sea level, 940 feet.

Test made at property of General Petroleum Company, Sec. 6. (Formerly Esperanza Oil and Gas Company.)

Names of observers, H. G. Anderson and H. W. Bell.

Gravity of oil at beginning of test, 16.4°.

Gravity of oil in pan at end of test, 13.2°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
May 2d, standard		90°	
	45°	92	
	46	93	60
	58	86	
	62	91	40
	52	96	
	58	90	40
	60	88	
	50	87	
	52	86	
	58	98	40
	68	90	
	56	84	
May 15th	52	84	
	52	88	35
	54	90	
	58	92	
	60	94	
	60	92	20
	54	90	
	56	86	
	54	72	
	54	70	
May 25th*	54	70	20
Average	55°	87°	
Mean, 71°.			
Total cups			255

*Shower on 25th ended test.

Test With Roof ½ Inch Above Pan.

No. 1. May, 1914.

Field, Coalinga, West Side. Elevation above sea level, 860 feet.
Test made at property of British Consolidated Oil Corporation, Ltd.
Name of observer, R. S. Haseltine.
Gravity of oil at beginning of test, 12.8° to 12.9°.
Gravity of oil in pan at end of test, top of pan 12.75°, bottom 12.5°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
May 1st	Pan filled	85°	
	53.5°	85	
	52	86	
	48.25	86.5	
	55.5	87.5	
	59	92	
	48.25	85.5	
	51.75	80.5	
	53.5	72	
	50	84	17
	53.5	85	
	57.25	98.25	
	60.75	93.25	
	52.75	84.25	
May 15th	50	84	
	49	85.5	
	51	88.75	
	57.25	90	
	59	99	10
	60	91	
	60.75	89.5	
	51	78	
	50	69	
	57.25	70.75	
	57.25	68	
	53.5	83.75	
	57.25	90.5	
	55.5	92.25	
	61.75	100	
May 30th	66.25	106.75	14
Average	55°	86°	
Mean, 70°.			
Total cups			41

Test With Roof ½ Inch Above Pan.

No. 2. June, 1914.

Field, Coalinga. Elevation above sea level, 807 feet.
Test made at property of The American Petroleum Company.
Name of observer, T. J. Crumpton.
Gravity of oil at beginning of test, 15.9°.
Gravity of oil in pan at end of test, 14.9°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
June 1st	66°	96°	16
	62	90	16
	52	88	10
	58	86	16
	56	74	8
	48	68	8
	56	70	10
	48	82	8
	52	84	10
	58	90	10
	56	92	16
	52	90	12
	56	94	8
	66	94	12
June 15th	60	94	16
	60	96	10
	72	102	18
	74	92	12
	68	84	12
	60	88	20
	54	92	15
	60	98	12
	58	96	15
	56	82	15
	54	84	10
	56	92	15
	60	100	10
	70	110	10
	76	108	10
June 30th	74	104	30
Average	60°	91°	
Mean, 75°.			
Total cups			390

Test With Roof ½ Inch Above Pan.

No. 3. June, 1914.

Field, Midway (Taft, Cal.). Elevation above sea level, 1,010 feet.
Test made at property of General Petroleum Company.
Name of observer, I. W. Martin.
Gravity of oil at beginning of test, 22.8°.
Gravity of oil in pan at end of test, 18.3°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
June 1st	68°	100°	
	66	87	100
	64	95	60
	68	92	90
	59	73	65
	52	80	20
	54	70	36
	56	85	13
	62	88	18
	65	94	17
	68	97	20
	60	88	22
	62	94	12
	74	100	10
June 15th	68	103	20
	75	102	15
	76	108	10
	78	100	22
	66	103	16
	68	98	16
	60	92	14
	65	98	13
	66	95	10
	58	90	15
	60	87	10
	62	94	3
	66	95	10
	70	110	10
	68	115	8
June 30th	71	112	5
Average	65°	93°	
Mean, 79°.			
Total cups			680

Test With Roof ½ Inch Above Pan.

No. 4. May-June, 1914.

Field, Coalinga. Elevation above sea level, 1,012.25 feet.
Test made at property of California Oilfields, Limited.
Name of observer, Wm. Dron.
Gravity of oil at beginning of test, 22.8°.
Gravity of oil in pan at end of test, 18.7°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
May 20th	60°	92°	
	58	88	
	59	91	46
	50	89	
	51	76	12
	51	76	10
	51	84	
	58	85	8
	60	99	4
	60	100	
	58	102	
May 31st	59	104	20
June 1st	59	115	20
	62	92	
	56	92	
	52	90	
	50	88.5	30
	52	84	
	52	84	
	51	91	
	51	98	
	57	102	
	54	102	
	50	106	30
	54	110	
	61	118	
June 15th	62	119	
	71	110	
	72	122	
	70	118	
June 19th	62	98	30
Average	57°	98°	
Mean, 77°.			
Total cups			210

Test With Roof ½ Inch Above Pan.

No. 5. May-June, 1914.

Field, Coalinga West Side. Elevation above sea level, 940 feet.

Test made at property of General Petroleum Company, Section 6. (Formerly Esperanza Oil and Gas Company.)

Names of observers, H. G. Anderson and H. W. Bell.

Gravity of oil at beginning of test, 16.8°.

Gravity of oil in pan at end of test, 15.3°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
May 30th, standard		106°	
	68°	106	
June 1st	68	103	
	58	100	60
	54	98	
	58	92	
	54	84	
	52	72	40
	60	70	
	52	88	
	58	94	
	60	100	
	62	96	20
	54	93	
	58	101	
	66	106	
June 15th	68	105	
	66	100	
	66	114	15
	80	97	
	70	90	
	64	96	
	56	96	
	62	99	15
	62	100	
	60	87	
	58	86	
	58	102	
	64	106	
	70	114	
June 29th	76	End 8 a.m.	16
Average	62°	97°	
Mean, 79°.			
Total cups			166

Test With Roof 4½ Inches Above Pan.

No. 2. July, 1914.

Field, Coalinga. Elevation above sea level, 802 feet.
Test made at property of American Petroleum Company.
Name of observer, T. J. Crumpton.
Gravity of oil at beginning of test, 15.2°.
Gravity of oil in pan at end of test, 15.0°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
July 1st	70°	100°	10
	68	104	15
	60	98	18
	60	98	25
	62	100	15
	70	104	20
	66	102	27
	64	102	26
	67	96	20
	62	96	18
	59	98	16
	55	92	21
	59	92	23
	66	96	24
July 15th	69	92	18
	74	84	15
	68	102	8
	72	98	10
	68	102	12
	63	98	15
	61	96	10
	63	96	8
	65	104	6
	69	110	6
	68	102	8
	69	100	10
	62	94	6
	63	102	10
	65	102	6
	65	106	6
July 31st	63	104	20
Average	65°	99°	
Mean, 82°.			
Total cups			452

Test With Roof 4½ Inches Above Pan.

No. 3. July, 1914.

Field, Midway (Taft, Cal.). Elevation above sea level, 1,010 feet.
Test made at property of General Petroleum Company.
Name of observer, I. W. Martin.
Gravity of oil at beginning of test, 23.0°.
Gravity of oil in pan at end of test, 18.7°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
July 1st	72°	104°	125
	62	103	97
	60	104	63
	66	106	42
	60	104	40
	62	103	30
	65	100	25
	68	106	19
	62	94	25
	59	93	16
	60	95	10
	65	102	11
	68	106	9
	78	100	23
July 15th	75	106	5
	72	107	10
	74	105	12
	73	103	16
	68	104	13
	67	102	
	64	107	12
	66	100	8
	72	100	6
	72	107	9
	68	106	12
	66	103	7
	66	106	9
	68	107	2
	68	107	8
	66	106	6
July 31	68	107	4
Average	67°	103°	
Mean, 85°.			
Total cups			674

Test With Roof 4½ Inches Above Pan.

No. 4. May-June, 1914.

Field, Coalinga. Elevation above sea level, 1,012.25 feet.
Test made at property of California Oilfields, Limited.
Name of observer, Wm. Dron.
Gravity of oil at beginning of test, 22.8°.
Gravity of oil in pan at end of test, 18.7°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
May 20th	60°	92°	
	58	88	
	59	91	76
	50	89	
	51	76	16
	51	76	16
	51	84	
	58	85	10
	60	99	5
	60	100	
	58	102	
May 31st	59	104	25
June 1st	59	115	35
	62	92	
	56	92	
	52	90	40
	50	88.5	
	52	84	
	50	90	
	51	91	
	51	98	
	57	102	
	54	102	
	50	106	40
	54	110	
	61	118	
June 15th	62	119	
	71	110	
	72	122	
	70	118	
June 19th	62	98	35
Average	57°	98°	
Mean, 77°.			
Total cups			298

Test With Roof 4½ Inches Above Pan.

No. 5. June-July, 1914.

Field, Coalinga, West Side. Elevation above sea level, 940 feet.

Test made at property of General Petroleum Company, Section 6. (Formerly Esperanza Oil and Gas Company.)

Names of observers, H. G. Anderson and H. W. Bell.

Gravity of oil at beginning of test, 18.0°.

Gravity of oil at end of test, 14.9°.

	Temperature		Number of cups
	5 a. m.	2 p. m.	
June 29th, standard	------------	114°	
	76°	115	
July 1st	74	114	70
	74	109	
	70	106	50
	66	104	
	69	104	
	70	106	
	70	106	30
	68	103	
	66	105	
	68	105	
	62	99	30
	58	101	
	58	100	
	64	106	
July 15th	62	108	
	70	92	
	70	105	25
	76	104	
	74	104	
	68	103	
	65	104	
	68	106	20
	68	108	
	72	113	
	72	113	
	76	109	
	70	110	
	68	106	
July 29th	70	------------	23
Average	67°	106°	
Mean, 87°.			
Total cups	------------	------------	248

A summary of the results of the one month's tests is—

Cover Raised One Half Inch.

Number of test	Gravity, Baume		Temperature, mean	Average loss per day, inches
	Initial	Loss		
1—½	12.8°	0.2°	70	.0026
2—½	15.9°	1.0°	75	.0200
5—½	16.8°	1.5°	79	.0107
3—½	22.8°	4.5°	79	.0453
4—½	22.8°	4.1°	77	.0135

Cover Raised Four and One Half Inches.

2—4	15.2°	0.5°	82	.0301
5—4	18.0°	3.1°	87	.0166
3—4	23.0°	4.3°	85	.0435
4—4	22.8°	4.1°	77	.0192

Cover Removed.

1—0	12.8°	0.2°	70	.0087
2—0	14.7°	0.7°	82	.0318
5—0	16.4°	3.2°	71	.0204
3—0	22.7°	5.7°	73	.0508
4—0	22.8°	4.1°	77	.0269

It will be readily noted that a test under these conditions should not be conducted for thirty days' time. The greatest loss, in most cases, occurred in the first five or ten days, and after that time the loss was small and rather uniform. As was already supposed, the lighter oils lose more in quantity and also in quality than do the heavier oils under similar conditions. Future tests should last for only five or ten days and the gravity observed daily.

The last test recorded in each of the three above summarized groups is erratic, showing a very small loss as compared with the others.

It would be unsafe to apply general results to all oils.

The following table is made from the figures showing maximum loss (during the first day), by four of the tests in an open pan. Almost no carefully made records were available showing loss actually measured at tanks or reservoirs, but such as were found indicate that the loss in an open pan during the first day is two or three times that occurring regularly over a long period of time, in an ordinary storage tank. Probably tests for a few days with cover raised ½ inch give results approximating actual and continuous loss in tanks.

Loss During First Day in Open Pan.

Gravity, Baume	Inches. Mean temperature 80° to 90° Fahr., or about maximum for California fields	Equivalent barrels in various sized tanks			Reported occurrences in tanks, inches
		55,000 (1 inch equals 151 barrels)	37,000 (1 inch equals 103 barrels)	10,000 (1 inch equals 28 barrels)	
13°	.010	1.51	1.03	0.28	.013, .004
14°	.036	5.44	3.71	1.02	
15°	.062	9.37	6.39	1.76	
16°	.088	13.30	9.07	2.50	
17°	.114	17.23	11.75	3.24	
18°	.140	21.16	14.43	3.98	
19°	.166	25.09	17.11	4.72	
20°	.192	29.02	19.79	5.46	
21°	.218	32.95	22.47	6.20	
22°	.244	36.88	25.15	6.94	
23°	.270	40.81	27.83	7.68	.107
25°-28°					.546

Evaporation, of course, carries away the lightest or most valuable portions of the oil, hence losses should not be figured as low as the market price of the crude oil, but possibly as high as the price of gasoline. Under such an assumption and with losses only one half as high as those indicated in the above table, our total storage of about fifty million barrels (if averaging only 18° B.) suffers a loss of some ten thousand barrels per day. At ten cents a gallon (not unreasonable for gasoline) this amounts to a daily loss of $42,000, or more than 25 per cent of the value of our daily production at the well.

Efficient methods of operation, frequently boasted of, call for tests that entirely disprove our calculation, or for methods that will cut down the losses. Small operators who run oil into open sumps or ditches of course have larger losses than those outlined.

In this connection it may be well to point to the fact that for many years gas escaped from wells and was entirely lost. Now gasoline is extracted from it and saved.

The following measurements of evaporation loss were made at five 55,000 barrel tanks in the San Joaquin Valley. Little is known as to the accuracy or methods of measurements, aside from the fact that they were made during the ordinary course of business.

Gravity, 22° to 24° Baume.

Average temperature of tank	Days	Loss, barrels	Loss, barrels per day
61°	10	75.5	7.5
62°	10	76	7.6
63°	13	114	8.8
64°	13	151	11.6
64°	10	226	22.6
63°	10	75	7.5
60°	11	114	10.3
60°	31	188	6.1
62°	10	230	23.0
63°	11	115	10.5
Average			11.5
76°	22	553	25.2
74°	7	228	32.6
78°	7	57	8.1
79°	21	286	13.6
77°	13	340	26.2
82°	19	249	13.1
83°	13	75	5.8
81°	9	114	12.7
Average			17.1
98°	16	244	15.2
95°	11	170	15.4
98°	22	173	7.9
Average			12.8

The following evaporation losses are reported for 14.8° Baume oil stored in a concrete lined reservoir in the Kern River field. The temperature of the oil was taken each month when the reservoir was gauged.

	Loss, barrels
April temperature, 64° Fahrenheit	1,388.40
May temperature, 66° Fahrenheit	830.56
June temperature, 68° Fahrenheit	505.97
July temperature, 72° Fahrenheit	1,304.00
August temperature, 72° Fahrenheit	585.18
Total	*4,614.11

*Loss of 1.87 inches in depth.
506,671.23 barrels originally stored.
502,057.12 barrels finally stored.

Diameter of reservoir at top 460 feet (1 foot = 29,623 barrels, 1 inch = 2,469 barrels). Hence the loss was about 0.012 inches per day.

Incidentally it is worthy of notice to what degree of accuracy gauging may reasonably be made. No doubt the total loss of five months, which caused the level of oil to fall 1.87 inches, might be approximately measured. The smallest monthly loss of 505 barrels would, however, be only .204 inches in depth, and its measurement might be in error as much as 50 per cent to 100 per cent. Accounting for decimal parts of a barrel is an utter absurdity.

TEMPERATURE CORRECTION IN MEASURING OIL.

The coefficient of expansion of oil is a figure constantly used in buying and selling and the figure should be fairly correct. It is customary to deduct 1 per cent from the measured volume for each 20° Fahrenheit above 60° (equivalent to a coefficient of .0005, which is correct for Eastern oils).

The accompanying diagram (Fig. 5) shows the coefficient of expansion for various oils at various temperatures, the figures being obtained by tests in a private laboratory.

It will be noted that the ordinary coefficient of .0005 is not correct when applied to California oil, but it should be about .00038, or 1 per cent for 25° Fahrenheit. It will also be noted that no definite and general rule can be applied to all oils. Furthermore, the coefficient of expansion varies at different temperatures.

The loss to a producer selling under the present rule is very slight as shown by the following figures for a delivery at 120° Fahrenheit:

1,000 barrels net = 1,030.9 gross at 1 per cent per 20° Fahrenheit
1,000 barrels net = 1,024.6 gross at 1 per cent per 25° Fahrenheit

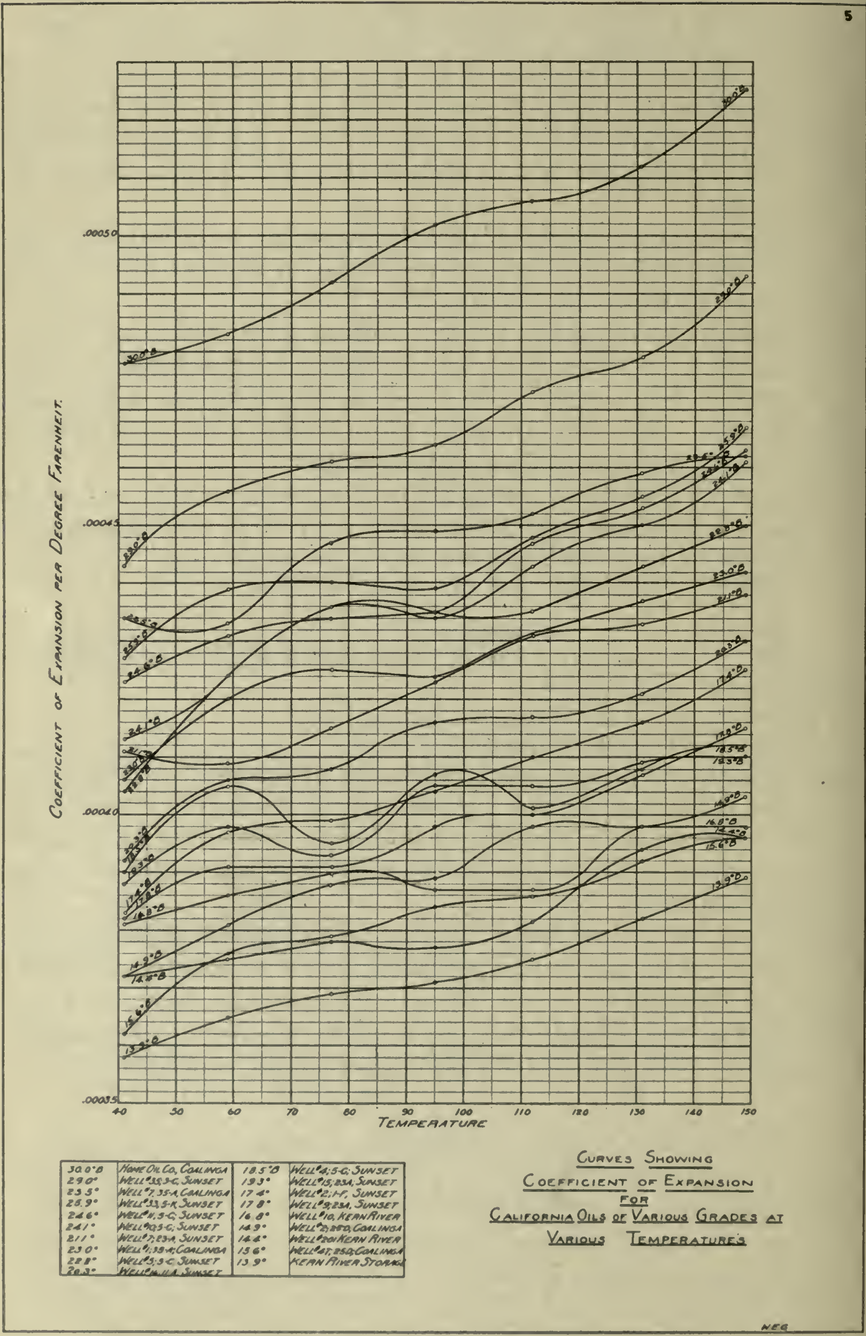
Difference........ 6.3 barrels

If sold at 50 cents per barrel, or a total of $500.00, the price per gross barrel would be

At 1 per cent per 20° Fahrenheit, 48.5 cents
At 1 per cent per 25° Fahrenheit, 48.8 cents

or a difference of three tenths of a cent per barrel. Furthermore, this loss is balanced by the fact that all the marketing concerns sell by the same rule and any change of method would be merely a readjustment of prices. The subject is therefore of scientific but not great practical interest.

The fact that a more nearly correct figure was not determined and used many years ago is an illustration of the cheerful disregard of technical facts under which the oil business has been conducted. Doubtless another decade will reveal other and greater discrepancies now spoken of as facts determined by ''scientific investigation.''



30.0°B	HOME OIL CO., COALINGA	18.5°B	WELL°4; 5-G; SUNSET
29.0°	WELL°35; 3-G, SUNSET	19.3°	WELL°15; 23A; SUNSET
23.5°	WELL°7, 35-A, COALINGA	17.4°	WELL°2; 1-F, SUNSET
25.9°	WELL°33, 5-K, SUNSET	17.8°	WELL°9; 23A, SUNSET
24.6°	WELL°11, 5-G; SUNSET	16.8°	WELL°10, KERN RIVER
24.1°	WELL°10; 5-G; SUNSET	14.9°	WELL°2, 25D, COALINGA
21.1°	WELL°7; 23A, SUNSET	14.4°	WELL°201 KERN RIVER
23.0°	WELL°1; 33-A; COALINGA	15.6°	WELL°4T, 25D, COALINGA
22.8°	WELL°5; 3-C SUNSET	13.9°	KERN RIVER STORAG
20.3°	WELL°14, 11A, SUNSET		

Fig. 5.

PHYSICAL AND CHEMICAL PROPERTIES OF CALIFORNIA OILS.

Numerous chemical and physical tests have been made upon California oils and the results published (California State Mining Bureau, Bulletins 31, 32 and 63; United States Bureau of Mines, Bulletin 19 and Technical Paper 74) hence a tabulation here is unnecessary. Unfortunately there is a considerable gap between laboratory results and refinery practice. In determining "commercial values" the large refineries depend upon an actual run in a small still, rather than an analysis. In view of such a condition and the wide discrepancy between analytical results as published by various investigators, further investigation is necessary before economic relations can be expressed in valuable form.

There are no statistics showing the total yield of various refined products in California. There are no fixed definitions or specifications for the various products. The public certainly needs considerable education if oil products are to be intelligently purchased.

Weight and Specific Gravity of Oil.

$$\text{Sp. Gr } \frac{60^\circ}{60^\circ} \text{ F.} = \left.\frac{140}{130 + \text{deg. B.}}\right\} \text{ Corresponding to degrees Baumé.}$$

(U. S. Bureau of Standards—Circular 19.)

Degrees Baumé	Specific gravity	Pounds per gallon	Pounds per barrel (42 gallons)	Barrels per ton (2,000 pounds)
10°	1.0000	8.34	349.9	5.72
11°	.9929	8.28	347.3	5.76
12°	.9859	8.21	344.8	5.80
13°	.9790	8.16	342.7	5.84
14°	.9722	8.10	340.2	5.89
15°	.9655	8.05	337.7	5.93
16°	.9589	7.99	335.6	5.97
17°	.9524	7.93	333.1	6.01
18°	.9459	7.88	331.0	6.04
19°	.9396	7.83	328.9	6.08
20°	.9333	7.78	326.8	6.12
21°	.9272	7.72	324.2	6.17
22°	.9211	7.67	322.1	6.21
23°	.9150	7.62	320.0	6.25
24°	.9091	7.57	318.0	6.29
25°	.9032	7.53	316.3	6.33
26°	.8974	7.48	314.2	6.37
27°	.8917	7.43	312.1	6.41
28°	.8861	7.38	310.0	6.45
29°	.8805	7.34	308.3	6.49
30°	.8750	7.29	306.2	6.54
31°	.8696	7.24	304.1	6.58
32°	.8642	7.20	302.4	6.62
33°	.8589	7.15	300.3	6.67
34°	.8537	7.11	298.6	6.70
35°	.8485	7.07	296.9	6.73
36°	.8434	7.03	295.3	6.77
37°	.8383	6.98	293.2	6.83
38°	.8333	6.94	291.5	6.86
39°	.8284	6.90	289.8	6.90
40°	.8235	6.86	288.1	6.95

Heating Value of California Oil.

(J. N. Le Conte, Journal American Society Mechanical Engineers, 1910.)

Degrees Baumé	British thermal units per pound	British thermal units per barrel
10°	18,280	6,398,600
11°	18,340	6,374,100
12°	18,400	6,349,800
13°	18,460	6,325,900
14°	18,520	6,302,400
15°	18,580	6,279,300
16°	18,640	6,256,500
17°	18,700	6,234,000
18°	18,760	6,211,400
19°	18,820	6,189,700
20°	18,880	6,167,900
21°	18,940	6,147,000
22°	19,000	6,126,000
23°	19,060	6,104,500
24°	19,120	6,084,400
25°	19,180	6,063,800

This table emphasizes the difference in marketing measure. It will be noted that the light or commercially valuable oils have less heating value per barrel than do the heavy oils.

SOME COMMERCIAL USES OF CALIFORNIA OIL.

Fuel Oil on Railroads.

Doubtless the largest consumption of California fuel oil is by the railroads. In 1913 the Southern Pacific alone burned about 32,000 barrels daily, according to evidence presented to the California Railroad Commission, and the expectation is that each year will see this figure increased by 2,000 to 2,500 barrels.

Heating value by tests on 745 locomotives show one ton (2,000 pounds) of ordinary bituminous coal (13,350 British thermal units) equal to 3.62 barrels of oil, and on eleven steamboats running six months 3.49 barrels.[1]

Consumption in running over the Sierra Nevada Mountains was from 35 to 49 gallons per 1,000 ton miles. Usually the oil is 14° to 15° Baumé, but the specifications are very broad, covering the five following points: (1) Viscosity, such as to flow freely through a 4-inch pipe at 70° Fahrenheit; (2) Water content less than 2 per cent using gasoline in the testing machine; (3) Flash less than 110° Tagliabue; (4) Temperature standard 60° with a correction of 1-25 per cent per degree; (5) Gravity 14° to 29° Baumé.

Oil for Gas Generation.

On the list of large consumers of crude oil the gas manufacturers stand near the head. There were fifty-six gas plants using oil as early as 1910.[2] The rate of consumption per thousand feet of gas generated is 8.13 to 8.55 gallons, about 15 per cent to 16 per cent of that amount being consumed as fuel for the retorts. The most suitable oil is 14° to 17° Baumé with less than 1 per cent sulphur.

Panama Canal.

The Panama Canal construction has consumed considerable oil, a six-year contract having been made in 1909 with the Union Oil Company at $1.10, the monthly deliveries being 30,000 to 60,000 barrels. At such a price the oil was cheaper than Pocahontas coal at $6.25.

Displacement of Coal.

The amount of coal imported and used in California has declined greatly since the year 1900, when the Kern River field was developed. The importation of coal in the year 1865 was 150,141 tons, and the amount increased steadily to 1,889,128 tons in 1900, when a rapid decline began and imports are now less than 500,000 tons. In other words, oil has actually displaced at least 1,400,000 tons of coal, and at

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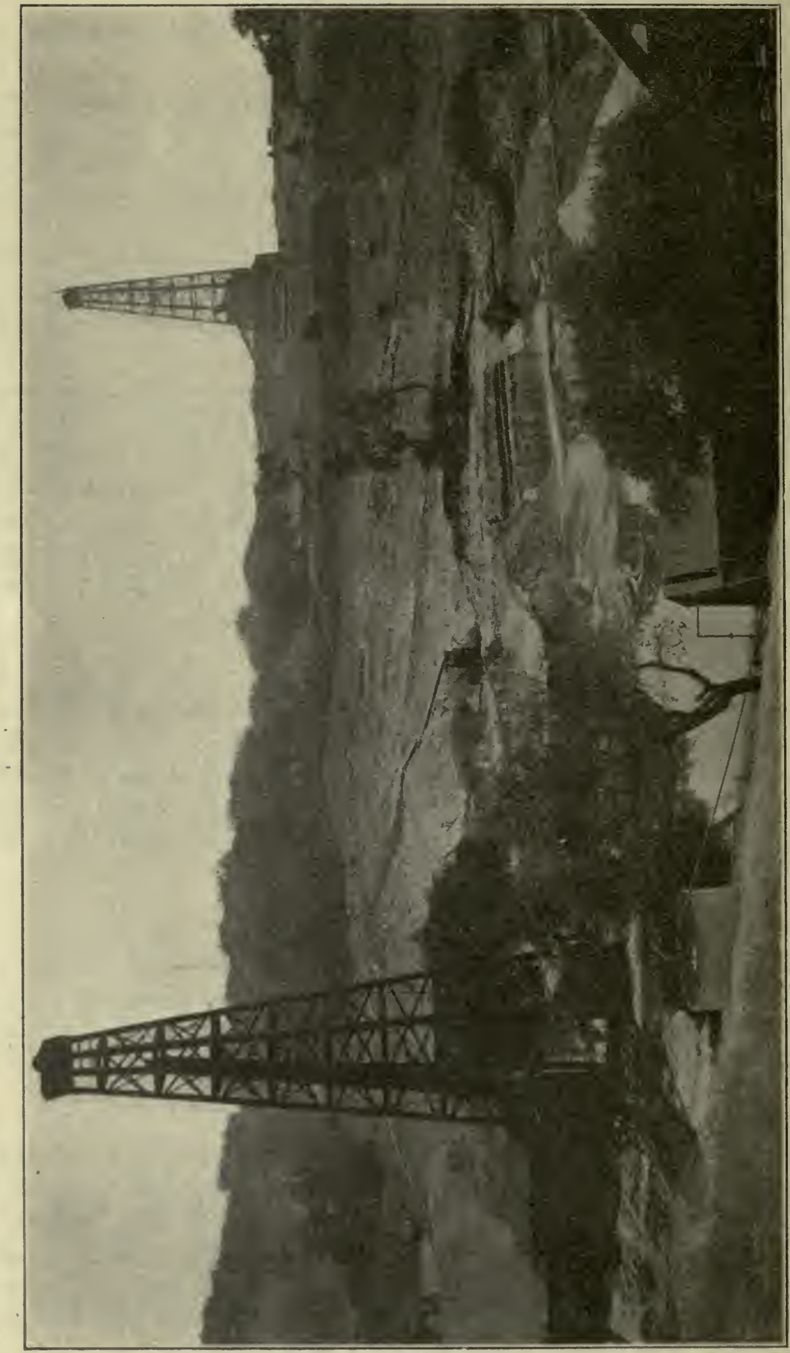
[1] Howard Stillman, Journal Am. Soc. Mechanical Engineers, 1911.

[2] E. C. Jones, Journal Electricity, Power and Gas, Vol. 24, pp. 492-501.



Typical sumps of oil near wells. Cat Cañon Field. Photograph by R. B. Moran.

the rate at which the importation steadily increased from 1865 to 1900 (50,000 tons per year) the imports would now probably have been 2,550,000 tons, hence the displacement is probably as high as 2,000,000 tons per year, or some seven million barrels of oil are now being burned annually in California in place of coal.

Diesel Engines.

The development of Diesel engines doubtless opens new fields for oil consumption and bids fair to become a very important factor. The engine operation will not be described here further than to say that fuel oil is sprayed into the cylinder and ignites, due to the heat of the compressed air. The oil does not explode, as does gasoline in an engine, but simply ignites and the combustion products expand.

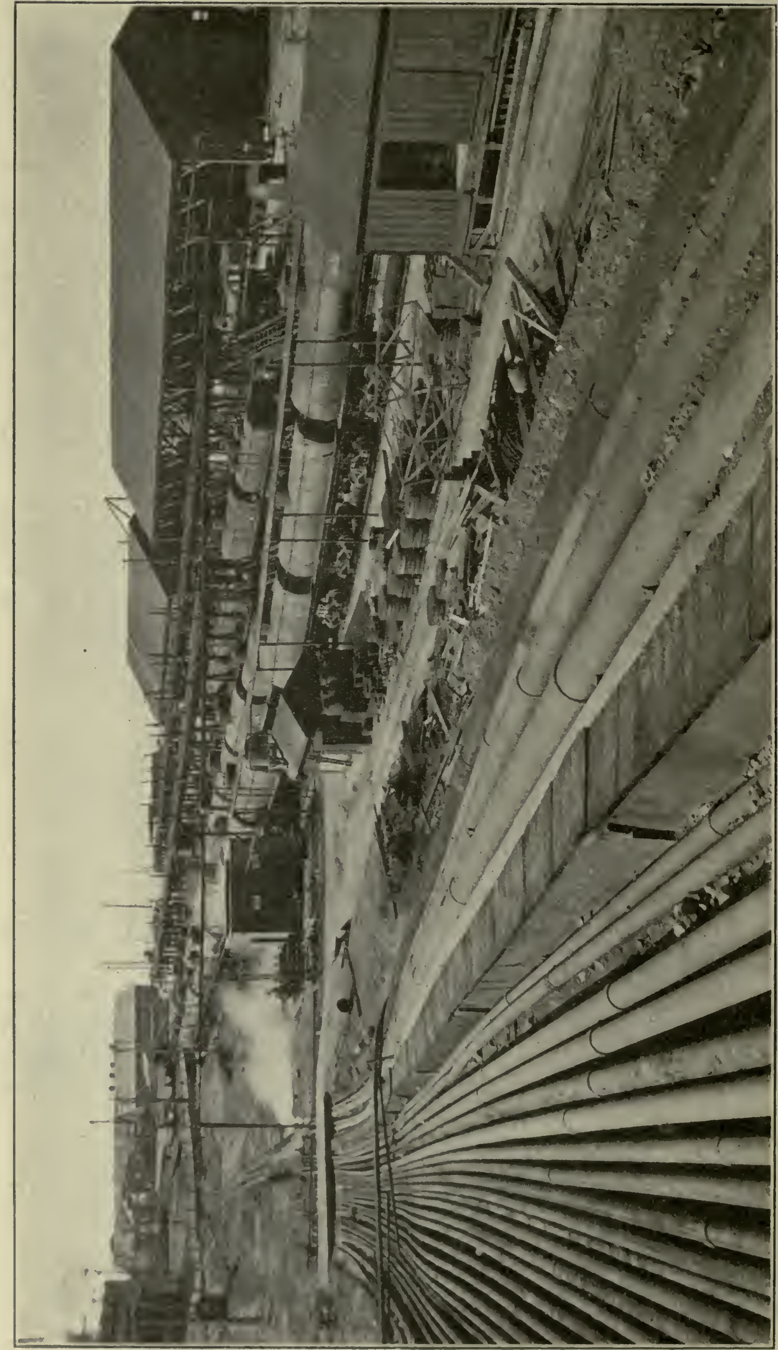
Fuel used for these engines, when dependent upon California products, is usually a treated oil turned out by the refineries, and selling under various trade names as fuel oil. Inquiry of oil manufacturers obtained little or no definite information as to the properties of their products. Dealers in engines assisted in furnishing information, notably Henry Lund & Company, and Busch-Sulzer Diesel Engine Company, both represented in San Francisco. Mr. T. C. Roberts of the United Verde Copper Company also gave us valuable information.

One of the usual oils has the following analysis:

24° Baumé (specific gracity .9091).
Open flash 180° Fahrenheit.
Closed flash 165° Fahrenheit.
Burning point 235° Fahrenheit.
Asphaltum 25 per cent.
Sulphur $\frac{3}{4}$ per cent.
British thermal units per pound 19,200.

Consumption of fuel varies from .525 pounds to .721 pounds per brake horsepower hour.

The United States Bureau of Mines (Technical Paper 37) has dealt more fully with the subject of heavy fuel oil for internal combustion engines. That paper shows that one pound of oil used in a Diesel equals two and one-half pounds used as fuel for a turbine or four pounds of coal.



Loading railroad cars with oil at a Standard Oil Company plant.

CHAPTER III.

OIL PIPE LINES.

The transportation of California oil by pipe lines is done by several companies; the extent and location of the lines is shown by the map, plate XVIII in the accompanying folio. The usual procedure is about as follows:

In each of the oil fields there is a gathering system of pipes from two to six inches in diameter. They radiate from large storage tanks at a pump station on the main line and extend to the various producing properties. At each producing property there are storage tanks or reservoirs large enough to hold an accumulated production of several days or weeks. When a run of oil is to be made a representative of the pipe line company, called a ''gauger,'' measures the depth of oil in the tank, and its temperature, and takes samples. He then unlocks and opens the gate valve which admits the oil to steam pumps which force it through the gathering pipe to the main pump station. When the storage tank at the producing property is about empty the valve is locked by the gauger and the depth again measured. A run ticket is issued to the producer, showing the temperature, gravity, percentage of water and sediment, and the two measured depths.

The various grades of California oil act very differently in a pipe line, and the subject is very intricate from an engineering standpoint. The low gravity oils are very thick or viscuous at ordinary temperatures, and to flow readily require heating. The lighter oils flow more freely and some require no heating. Some very interesting facts were published in the Journal of American Society of Mechanical Engineers, July, 1914. It is to be hoped that the pipe line companies will in the future realize that they owe considerable to the engineering profession and that all such debts to civilization are only repaid by giving publicity to technical results. Pipe lines costing millions of dollars are built largely upon ''rule of thumb'' methods.

The usual diameter of pipe on the main lines is eight inches. Pumping stations are placed from twelve to fifteen miles apart. The oil enters the line under a pressure of from 600 to 800 pounds per square inch, and is sometimes heated to a temperature of 150° or 160° Fahrenheit. The loss of temperature and increase in viscosity depend upon the weather conditions, nature of the ground in which pipe is buried and the kind of oil, so there is no definite distance at which stations can be placed. Upon reaching the next station the oil sometimes runs into storage tanks and sometimes goes directly to the suction pipes of the pumps. The temperature of heavy oil is usually not allowed to fall below 100° Fahrenheit while in the line.

The following daily record shows the varying conditions at a pump station on one of the 8-inch lines in the San Joaquin Valley:

April	Revolutions per minute	Line pressure, pounds	Temperature at 60° Fahr.	Gravity	Barrels pumped	Fuel, barrels
1	13.9	750	120	17.2	19,231	57.9
2	14.0	750	120	17.2	20,175	60.8
3	14.4	750	120	17.2	20,241	60.7
4	14.7	750	120	17.2	20,472	57.9
5	14.9 13.6	750	120	17.2	19,918	60.7
6	14.2	721	120	17.7	20,658	63.6
7	14.9	662	120	17.8	22,604	64.9
8	13.8	730	129	17.4	21,171	62.2
9	13.9	750	130	17.2	21,192	63.5
10	14.0	750	128	17.1	19,284	62.2
11	14.8	750	129	17.1	21,828	64.9
12	14.8	750	128	17.1	21,775	65.0
13	15.0	750	127	17.1	22,007	63.5
14	14.9	750	126	17.1	21,534	63.6
15	14.7	750	129	17.1	21,165	62.1
16	15.1	750	131	17.1	22,003	63.0
17	15.7	750	127	17.4	22,818	67.7
18	16.0	750	127	17.5	23,027	67.9
19	15.6	735	115	17.5	20,724	52.1
20	15.7	750	117	17.6	22,595	66.5
21	16.1	748	121	17.4	23,118	67.7
22	15.9	750	139	17.1	22,815	65.0
23	15.5	750	136	16.3	22,342	66.3
24	15.6	750	137	16.6	22,867	72.1
25	16.3	750	136	17.1	24,254	73.2
26	16.1	750	132	16.7	24,039	64.1
27	16.3	750	134	16.7	23,673	65.0
28	16.1	750	132	16.7	23,566	73.4
29	16.1	750	134	16.7	24,773	69.2
30	16.0	750	133	16.7	23,151	69.6
Totals					659,020	1,936.2

Atmospheric temperature, maximum 60° to 100°; daily range 20° to 25°.

The capacity of any line is subject to considerable variation due to changes of weather and grade of oil. It is usually aimed to handle the heaviest oil during the warmest weather, when that is possible. Frequently light oil is stored along the line, to be mixed in if the heavy oil becomes too cold and sluggish.

When a change is made from light, cold oil to heavy, hot oil, the temperature must be changed slowly to prevent the sudden expansion from breaking the pipe. The same care is necessary in changing back to cold oil. There is considerable contamination when a change is made from one grade of oil to another. The gravity of the oil at the receiving station changes gradually and no definite division exists between the two. The following records on the Producers' Transportation Company line show something of the action in a distance of sixty-one miles from Junction to Avila. Probably average conditions show smaller loss.

Junction Station, February 23, 1913, 5.05 a. m. Started pumping 31.8° gravity oil at speed of 1,000 barrels per hour. February 27th, 3.00 a. m., total delivery 46,874 barrels.

Avila, February 26th, 1.00 a. m., gravity 25°. February 28th, total receipts 45,244 barrels. Average gravity 27.3°.

Incoming gravity rose gradually from 28° to 30.9°. Last ten hours very irregular, from 31° to 19°.

Result: 12,000 barrels contaminated; 1,630 barrels lost.

Junction, July 31, 1913, 6.20 a.m. Started 23° oil into line at 1,000 barrels per hour to displace 15.8°. Temperature reduced from 142° at 6.00 a.m. to 100° at 7.00 a.m., when oil of 31.2° was started into line. Total delivery 55,199 barrels.

Sudden cooling of line caused break and delay of fifteen hours.

Avila, August 3d, 10.15 p.m. Oil of 26.5° arrived. Total receipts, August 5th, 11 p.m., 50,578 barrels.

Result: Apparent shortage of 4,621 barrels, but some figures were merely estimates.

Junction, July 21, 1912, 3.00 a.m. Started pumping 20° oil to displace 15.6°. Temperature reduced from 140° to 92° at 7.00 a.m., when 31.5° oil was put into line. Total delivery 42,662 barrels.

Avila. Gravity rose slowly and at 24.5° was turned into gauge tank. Total receipts 40,912 barrels. Average gravity 28.1°.

Result: 1,749 barrels lost by contamination with heavy oil. Distillation tests before and after showed 12 per cent and 6 per cent of 63.1° gasoline, but no details of tests are given.

A run of 47,882 barrels of 31.5° oil from Junction to Avila, October 17-21, 1912, showed receipt of 49,000 barrels of 28.8°.

Result: Contamination of light oil caused excess of 1,117 barrels in efforts to recover it.

Midway to Avila (via Junction) January 13th, 3.00 p.m.; 18th, 1.00 p.m., 1913. Total delivery 40,284 barrels, average 24.2°, relayed into tank of 31.5° at Junction which raised the gravity at that station from 23.4° to 27.5°. Receipt at Avila, 46,864 barrels; average 19.8°.

Result: Of the total delivery, 18 per cent was from the high grade relay tank which contained 12 per cent gasoline and over 20 per cent engine distillate. The remaining 82 per cent of the total delivery had started with from 2 per cent to 8 per cent gasoline and 16 per cent engine distillate. The resulting mixture contained no gasoline, 17 per cent distillate and 6 per cent kerosene, and was merely delivered for fuel oil.

Cost of constructing and operating pipe lines could be readily ascertained, if records of the various companies were available. However, it should be borne in mind that one of the largest factors is indefinite, namely, the length of time during which the line will be required to carry oil, because the life of an oil field is indefinite.

Considerable inquiry as to construction cost brought us but little definite information, but the following figures are probably about correct for an 8-inch station:

Building and stack	$6,900 00
Cottages (3)	4,500 00
Tool house	90 00
Tanks (two 3,700 barrels)	15,870 00
Feed tanks (two 100 barrels)	350 00
Feed tank (500 barrels)	510 00
Shed	490 00
Concrete and grading	4,300 00
Water well (?)	-------
Boilers (three 250 horsepower)	9,600 00
Pump—Main line	12,750 00
Pump—Fly wheel	16,100 00
Pump—Feed water (2)	900 00
Pump—Utility (2)	400 00
Pump—Fuel oil	220 00
Feed water heater	350 00
Oil heaters (2)	2,400 00
Generator and switch	600 00
Hot well	200 00
Suction (350′ 8″)	1,050 00
Pipe (miscellaneous)	310 00
Telephone set	10 00
Gas engine (4 horsepower)	280 00
Motor (3 horsepower)	120 00
	$78,300 00

It should be noted that more storage is frequently provided than is here shown, that the expense of a water well is sometimes great, and that no account is taken of land value.

The cost of the pipe varies considerably, but the following figures give a general idea:

	8 inch	6 inch
Pipe	$1.170 per ft.	$0.713 per ft.
Fittings	.060 per ft.	.050 per ft.
Hauling	.030 per ft.	.024 per ft.
Stringing	.010 per ft.	.008 per ft.
Painting	.050 per ft.	.040 per ft.
Ditching	.070 per ft.	.065 per ft.
Laying	.060 per ft.	.050 per ft.
Extra labor	.008 per ft.	.006 per ft.
Totals	$1.458 per ft.	$0.956 per ft.
Per mile	$7,698.04	$5,047.68
Telegraph line, per mile	400.00	400.00

The above items, if stations averaged twelve miles apart, would give a total cost of $14,631 per mile. It is frequently said that an 8-inch line costs $20,000 per mile, and in the absence of more records it can not be here disputed.

Operating cost, exclusive of repairs, may be indicated by the following station pay roll for one month:

2 engineers	$195 00
2 firemen	170 00
1 boiler washer	75 00
1 teamster	65 00
1 gauger	100 00
	$605 00

Therefore, pumping 659,000 barrels twelve miles, per month, would cost

Labor	$605 00
Fuel (1,936 barrels)	968 00
Depreciation, 12 miles, line (20 years at 6 per cent)	220 10
Depreciation, station (20 years at 6 per cent)	177 57
	$1,970 67

or .025 cents per barrel per mile.

It must be understood that this figure is merely an estimate and possibly not more than one half of what might be reasonably shown by some records. Furthermore this is bare cost without necessary overhead expense nor profit to the investor.

During 1912 the Producers' Transportation Company line handled 19,364,991 barrels of oil.

Total investment at the end of 1912, exclusive of rights of way, $5,307,205, including additions of $529,373 during the year.

Income Account.

Earnings	$1,882,021	64
Expense (operation, maintenance, tax and general)	393,749	54
Net earnings	$1,488,272	10
Reserve for depreciation	185,080	87
Net income	$1,303,191	23
Interest on bond and floating indebtedness	201,441	50
Surplus	$1,101,749	73

In this report the total expenditure, including depreciation and interest on indebtedness, was $780,271.91, or $.0403 per barrel. For an average distance of 120 miles this would amount to .033 cents per barrel per mile.

Rates for transporting oil are as follows, in the agreement under which the product of the Independent Oil Producers' Agency is moved by the Union Oil Company and Producers' Transportation Company.

Pipe Lines.

San Joaquin Valley fields:	
Wells to cars	2½¢ per barrel
Wells to Port Harford	22½¢ per barrel
Coast and Southern fields (*except Salt Lake*):	
Wells to cars, or vessels	10¢ per barrel
Salt Lake Field to Los Angeles	7½¢ per barrel

Vessels.

Port Harford to Eureka	20¢ per barrel
Port Harford to San Francisco	10¢ per barrel
Port Harford to San Diego	12½¢ per barrel
Port Harford to San Pedro	10¢ per barrel
Port Harford to Santa Barbara	7½¢ per barrel
Port Harford to Ventura	10¢ per barrel
Port Harford to Hueneme	10¢ per barrel
San Francisco Bay to Eureka	15¢ per barrel
San Francisco Bay to San Diego	17½¢ per barrel
San Francisco Bay to San Pedro	15¢ per barrel
San Francisco Bay to Santa Barbara	12½¢ per barrel
San Francisco Bay to Ventura	15¢ per barrel
San Francisco Bay to Hueneme	15¢ per barrel
San Pedro to San Diego	7½¢ per barrel
San Pedro to San Francisco	15¢ per barrel
San Pedro to Santa Barbara	7½¢ per barrel
San Pedro to Ventura	7½¢ per barrel
San Pedro to Hueneme	7½¢ per barrel

Storage in steel tanks is charged for at the rate of 1 cent per barrel per month. Storage in earthern reservoirs is charged for at the rate of 2 cents per barrel per year.

The principal pipe lines of California are owned by:

Standard Oil Company.
Producers' Transportation Company.
Union Oil Company.
Associated Pipe Line Company.
Associated Oil Company.
General Pipe Line Company.

The Standard Oil Company lines may be divided into four groups, serving (1) San Joaquin Valley; (2) Los Angeles and Orange counties; (3) Ventura County; (4) Santa Barbara County.

The following is a summary of the lines and branches:

STANDARD OIL COMPANY.

From	To	Length, miles	Size	Gravity	Daily capacity
Kern River	Richmond	280.6	2—8-inch 12-inch loop	15° 24°	65,000
Midway	Bakersfield	32.3	2—8-inch 12-inch loop	23°	65,000
Coalinga	Mendota	29.2	8-inch 6-inch loop		28,000
Lost Hills	Pond	21.1	8-inch	26°	20,000
Northan	El Segundo	23.9	6-inch and 8-inch	23°	27,000
Newhall	Ventura	44.9	2-inch and 3-inch	34°	1,400
Santa Maria	Port Harford	32.1			20,000

The Producers' Transportation Company serves the San Joaquin Valley, the lines being as follows, and carrying Agency and Union oil:

PRODUCERS' TRANSPORTATION COMPANY.

Stations	Elevation	Size	Length, miles	Total miles
Junction	707			
Antelope	1,205	2— 8-inch	12.7	
Shandon	1,091	8-inch	11.9	
Creston	1,099	8-inch	15.6	
Santa Margarita	974	8-inch	11.5	
Avila	117	8-inch	19.7	
Port San Luis	15	10-inch	2.6	74.0
Capacity, 30,000 barrels.				
Coalinga	663			
Tar Canyon	826	8-inch	15.2	
Dudley	595	8-inch	12.9	
Junction	707	8-inch	12.9	41.0
Capacity, 15,000 barrels.				
Sunset	636			
Midway	1,070	8-inch	6.2	
McKittrick	1,012	8-inch	15.9	
Middlewater	803	8-inch	15.2	
Junction	707	8-inch	13.0	50.3
Capacity, 20,000 barrels.				
Kern River	494			
Rio Bravo	314	8-inch	16.7	
Buttonwillow	270	8-inch	9.2	
McKittrick	1,012	8-inch	13.5	39.4
Lost Hills Line		6-inch	13.3	13.3
Belridge Line		6-inch	3.2	3.2
Total				221.2

The Union Oil Company lines serve (1) Santa Barbara County; (2) Ventura County, and (3) Los Angeles and Orange counties as follows:

UNION OIL COMPANY.

From	To	Size	Length, miles	Total miles
Orcutt	Port San Luis	8-inch 6-inch	64.94	64.94
Fillmore	Sespe	3-inch	9.75	
Sespe	Ventura	4-inch	23.00	
Ventura	Oxnard	4-inch	10.00	42.75
Stewart	Norwalk	6-inch	9.48	
Los Angeles	Norwalk	6-inch	14.26	
Sherman	Los Angeles	8-inch	10.96	
Norwalk	Bixby	8-inch	7.26	
Bixby	East San Pedro	6-inch	9.41	51.37

The Associated Pipe Line Company carries San Joaquin Valley oil belonging to the Southern Pacific Railroad and Associated Oil companies. The lines are peculiar in that they are rifled with the idea that water injected with the oil would, by the centrifugal force, keep next to the pipe and reduce friction. Data proving the plan to be economically successful have not been made public. There are two branches. The branch from Kern River is operated cold with heavy oil, while that from Midway and Coalinga carries lighter oil which is heated. Details are as follows:

ASSOCIATED PIPE LINE COMPANY.

From	To	Length, miles	Size	Capacity, barrels daily
Kern River	Port Costa	*281	8-inch	13,000
Sunset	Port Costa	278	8-inch	23,000

*Rifled.

The Associated Oil Company pipes oil from Coalinga to Monterey, and from Santa Maria to Gaviota. Both lines are over rough mountainous country, the Monterey line passing over a summit 2,600 feet above sea level. Details of the lines are as follows:

ASSOCIATED OIL COMPANY.

From	To	Length, miles	Size	Gravity	Capacity, barrels daily
Santa Maria	Gaviota	30	8-inch	24°	15,000
Cat Canyon	Gaviota	30	8-inch		8,000
Coalinga	Monterey	105	6-inch	16–17°	15,000

AMALGAMATED OIL COMPANY (ASSOCIATED OIL COMPANY).

From	To	Length, miles	Size	Gravity	Capacity, barrels daily
Salt Lake	Los Angeles	6.5	6, 4, 3-inch		9,000

The General Pipe Line Company carries oil for the General Petroleum Company from Sunset to Los Angeles, with a branch line which delivers oil at Mojave. This line traverses very mountainous country. Its highest elevation is 4,215 feet above sea level, at the summit of the Tehachapi Mountains. The details are as follows:

GENERAL PIPE LINE COMPANY.

From	To	Length, miles	Size	Gravity	Capacity, barrels daily
Midway	Los Angeles	156.0	8-inch	18°	25,000
Liebere	Mojave	51.8	8-inch		

EXPORTATION OF CALIFORNIA OIL.

The total exports of oil and its liquid products in 1913 from San Francisco Customs District was 7,824,316 barrels (42 gallons), or 8 per cent of the total production. Exports from the southern California Customs District are much less and hence seldom segregated.

The accompanying table gives in detail the shipments of California oil products from San Francisco to foreign countries. The largest consumer of either fuel oil or residuum is Chile, where operation of the nitrate deposits is an important industry. The oil on board ship at the Chilean ports is said to be about the same price per British thermal units as coal, but 6,000 tons of oil is pumped ashore in forty-eight hours while the equivalent fuel in the form of coal would require twenty men, two donkey engines, six barges and a locomotive for six weeks.* It will be noted that 5,165,629 barrels of fuel go to foreign ports.

Imports of oil at San Francisco for the year ending June, 1913, were as follows:

Crude, 16,736,715 gallons	$411,439 00
Benzine, 7,579,380 gallons	563,346 00

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*Mining and Scientific Press, September 5, 1914, p. 366.

PETROLEUM EXPORTS FROM SAN FRANCISCO, 1913.

(Third annual statistical report of the San Francisco Chamber of Commerce.)

From United States Custom House Records.

	Asphalt		Fuel oil		Residuum	
	Tons	Value	Gallons	Value	Gallons	Value
Australia and Tasmania	62	$730 00				
British Oceania						
Canada	4,181	44,948 00	51,374,704	$930,884 00	5,956,300	$130,662 00
Chile		11,395 00			106,905,012	1,723,708 00
China						
Colombia						
Costa Rica						
Dutch East Indies						
Ecuador						
England	210	1,922 00				
French Oceania						
Germania Oceania						
Germany						
Guatemala			4,494,000	80,700 00		
Honduras						
Hong Kong					1,680,000	26,000 00
India						
Italy						
Japan						
Korea						
Mexico						
New Zealand						
Nicaragua						
Panama					34,707,417	593,946 00
Peru					11,839,004	175,454 00
Philippine Islands						
Salvador						
Straits Settlements						
Tasmania (see Australia)						
Totals	4,453	$58,995 00	55,868,704	$1,011,584 00	161,087,733	$2,649,770 00
Average value		$13.20		$0.76 per bbl.		$0.69 per bbl.
Total barrels (42 gallons)			1,330,207		3,835,422	

PETROLEUM EXPORTS FROM SAN FRANCISCO, 1913—Continued.

	Coal oil		Lubricating oil		Naphtha		Total
	Gallons	Value	Gallons	Value	Gallons	Value	
Australia and Tasmania			283,431	$34,003 00			$34,733 00
British Oceania	2,100	$253 00					256 00
Canada	215,000	19,295 00	132,836	28,753 00	1,470,000	$183,375 00	1,340,917 00
Chile	69,742	7,665 00	2,754	505 00	17,748	2,560	1,745,833 00
China	38,185,875	1,738,101 00	59,589	6,339 00			1,744,440 00
Colombia	20,697	2,541 00	40	16 00			2,557 00
Costa Rica	19,059	2,201 00	1,965	488 00			2,689 00
Dutch East Indies	3,697,473	166,116 00	19,828	1,686 00			167,802 00
Ecuador					216	55 00	55 00
England							1,922 00
French Oceania	60,170	6,279 00	10,711	5,500 00	193,193	28,121 00	39,900 00
Germania Oceania	21,122	2,648 00			7,770	1,124 00	3,772 00
Germany			3,000	432 00			432 00
Guatemala	278,439	31,853 00	6,290	1,649 00			114,202 00
Honduras	35,900	4,030 00	455	112 00	11,785	2,410 00	6,582 00
Hong Kong	3,757,150	169,071 00					195,071 00
India	4,320,000	194,400 00	118,949	10,685 00			205,085 00
Italy			2,500	365 00			365 00
Japan	57,527,559	2,612,249 00	60,169	8,568 00			2,620,817 00
Korea			450	152 00			152 00
Mexico	20,626	2,914 00	55,975	16,324 00	11,353	1,263 00	20,531 00
New Zealand			120,088	25,428 00			25,428 00
Nicaragua	513,311	58,481 00	3,592	978 00	17,689	3,328 00	62,787 00
Panama	45,090	5,245 00			28,720	5,387 00	604,578 00
Peru			430	104 00			175,558 00
Philippine Islands			20,914	3,425 00			3,425 00
Salvador	153,827	17,197 00	9,018	2,499 00	26,682	5,464 00	25,160 00
Straits Settlements			23,534	1,984 00			1,984 00
Tasmania (see Australia)							
Totals	108,943,170	$5,040,602 00	936,518	$149,995 00	$1,785,156 00	$236,087 00	$9,147,033 00
Average value		$0.046 per gal.		$0.16 per gal.		$0.133 per gal.	
Total barrels (42 gallons)	2,593,885		22,298		42,504		

Coal oil is the most important refined product and finds most of its foreign market in Japan and China. The largest foreign consumer of California naphtha is Canada. Lubricating oil finds a wide market, about 70 per cent of the foreign sales going to British colonies.

Three companies are engaged in the distribution of oil by sea, viz: Associated Oil Company, Standard Oil Company and Union Oil Company, and the Shell Company is building ships. Their fleets and shipping points are as follows:

Associated Oil Company shipping from San Francisco Bay, Monterey, Gaviota and Redondo:

Steamer	Capacity (barrels)
Wm. F. Herrin	50,819
J. A. Chanslor	50,819
W. S. Porter	53,035
Coalinga	9,880
Marion Chilcott	16,814
Falls of Clyde	19,160
Monterey	19,408
Santiago	11,120
Frank H. Buck	65,000

Standard Oil Company shipping from Richmond and El Segundo. Coastwise and foreign:

Steamer	Capacity (barrels)
El Segundo	34,000
George Loomis	7,000
Capt. A. F. Lucas	40,000
J. A. Moffett	65,000
Maverick	12,000
Richmond	65,000
Asuncion	21,000
Atlas	16,000
Col. E. L. Drake	40,000
Barge 91	23,000
Barge 93	28,000
Barge 95	48,000

Union Oil Company shipping from Oleum, Port San Luis, Ventura, and San Pedro:

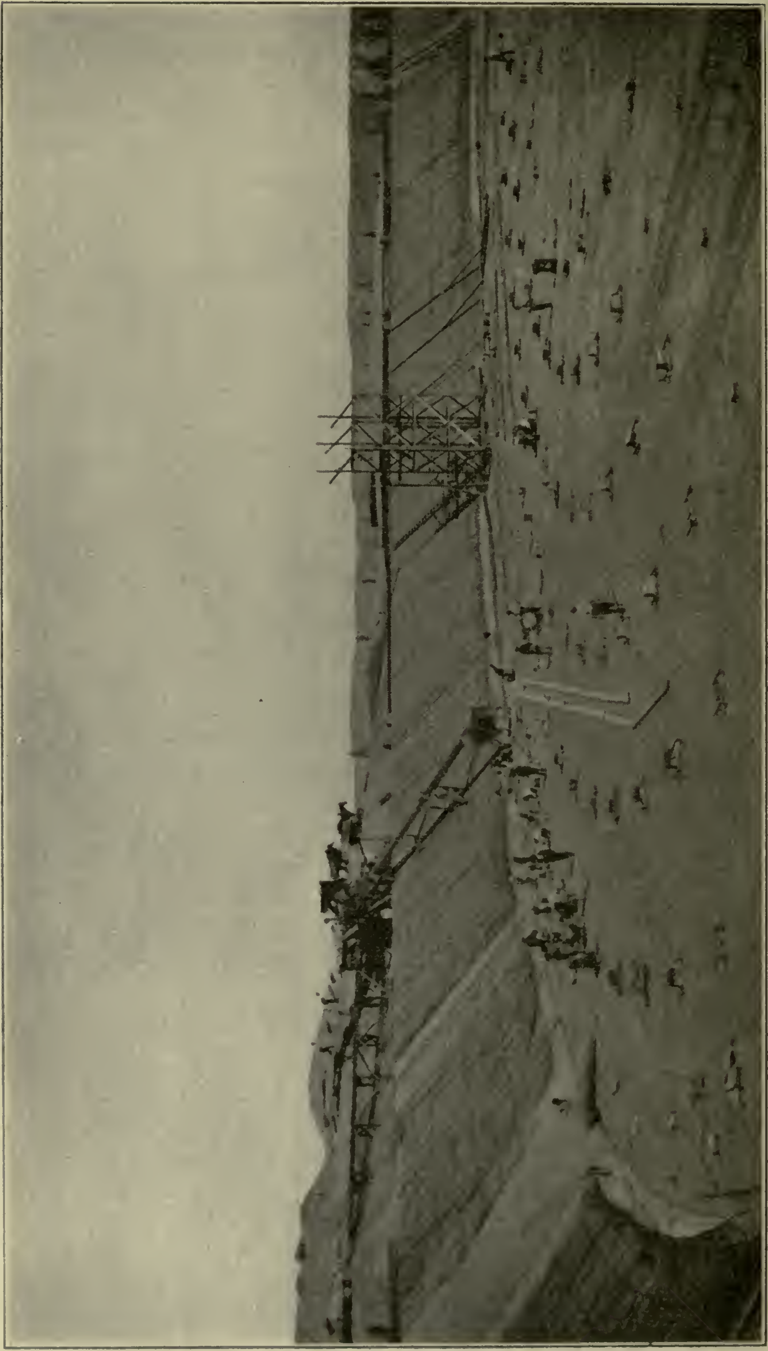
Steamer.	Capacity (barrels)
Argyll	28,000
Catania	21,000
Cordelia	66,000
Elsinore	66,000
E. M. Phelps	28,000
Fullerton	16,000
Lansing	48,000
La Habra	72,000
Oberon	52,000
Oleum	36,000
Pectan	72,000
Roma	26,000
San Joaquin	72,000
Santa Maria	50,000
Santa Rita	50,000
Simla	22,000
Trinculo	52,000
Washtenaw	27,000
Whittier	10,500

We had hoped to give the total shipments to domestic ports during 1913, but as only one company, the Union, furnished us its figures we were unable to do so.

Shipments of Oil by Rail.

According to returns from the Southern Pacific, Santa Fe, Western Pacific and Salt Lake railroad companies, there was taken out of the state in 1913 the following amounts of crude and refined oil, not including that used by the railroad companies:

Crude	4,263,547 barrels
Refined	422,307 barrels



Interior of concrete-lined earthen reservoir during construction. Photograph by E. D. Cole.

RESERVOIRS.

Concrete lined earthern reservoirs contain a great deal of the oil stored in California. The following facts are summarized from a typical contract in the Kern River field, and with the drawing in the folio (plate XVII), give all vital details of construction and cost.

SPECIFICATIONS FOR A 750,000 BARREL CONCRETE OIL RESERVOIR.

Diameter at bottom	462 feet
Diameter at top	528 feet
Depth	22 feet
Inside slope	1½ horizontal 1 vertical
Outside slope	1½ horizontal 1 vertical
Top of embankment	11 feet
Slope of top	6 inches in 11 feet
Area of bottom	167,600 square feet
Area of inside slope	61,600 square feet
Total area inside	229,200 square feet
Capacity of tank	750,000 barrels (42 gallons)

Materials.

Clay and sand at site of reservoir. Lumber and cement, etc., furnished by owners.

Foundation.

Foundation must be cleared of brush and grass, etc., then plowed, harrowed and moistened.

Embankment.

Embankment to be laid in three inch layers each compacted before laying more. No piles allowed. Wheel and Fresno scrapers used in moving the dirt.

Borrow Pits.

Nearest rim of pit to be 100 feet from outer wall of embankment. Farthest 200 feet.

Runways.

Any part of embankment that may be run smooth must be plowed and harrowed. Timber runways must be used when constructing inside slope.

Compacting.

After each fill earth must be compacted by means of at least two petrolithic road tampers and scraper teams. Each team making eight rounds per hour.

Inner Slope.

Slope to be made roughly the width of a wheel scraper, the outside line of the finished slope extending from the subbase to the top of the slope. The material to bring the slope to the required width is deposited in thin horizontal layers commencing sub-grade at bottom of reservoir. Moisten and tamp by passing teams, bond by means of plow. Trim down to true slope.

Top.

Build the top of the embankment one tenth of a foot higher and trim down to the required height.

Bottom.

Excavate the bottom of the tank one foot below the finished line, plow, moisten and compact. Finish in three inch layers as slope. Drain to swing pipes.

Drain and Oil Pipe.

There shall be one drain and three oil pipes imbedded in the bank as directed and shown on plan. Pipes to be painted.

Footings.

Make all footings for reservoir posts and footing for swing pipe as shown on plan and of concrete as herein specified.

Charges for Extra Work.

	Bid price per hour.
Foreman	$0.495
Laborer	.270
Driver	.300
One horse snaking	.150
Two horse snatch	.300
Three horse snatch	.450
Four horse snatch	.600
Two horse Fresno	.320
Two horse slip scraper	.320
Two horse wheel scraper	.330
Four horse Fresno	.618
Two horse plow	.320
Four horse plow	.620
Six horse plow	.920
Two horse wagon	.350
Four horse wagon	.650
Six horse wagon	.950
Eight horse wagon	1.250
Carpenter	.350
Wagon trailer	.050
Four horse tamper	.600

Costs.

Total cost, per barrel capacity, to build reservoir	$0.10	to	$0.11
Labor:			
Earthwork (per yard)	.30	to	.50
Concrete (per yard)	.70	to	.80
Roofing per M	5.00	to	6.00

Roof.

Framework.

Pitch of roof to be one half inch in one foot. Supports to be 6 x 6 and 6 x 8 posts, resting on concrete piers. Posts to be centered by ⅝ x 6 inch steel dowels. Posts set on concentric rings as shown, centered eighteen feet each way and tied together by 1 x 6 bracing. Cut posts as directed to give pitch. Top of posts connected with girders. Outside ring girders to be 4 x 16, all others to be 3 x 12. Post frame for girder and secure by means of ⅝ x 7 bolt and ⅛ x 2½ x 18 strap through which bolt passes and spike to girder.

Rafters.

Outside row of rafters to rest on 4 x 16 girders at inner end and 2 x 14 on the outer end. Redwood mud sill to be set on bank of reservoir as shown on drawings. Outside row of rafters to be 2 x 14 and to be stiffened by 3 rows of herring bone bridging. All others to be 2 x 8.

Sheathing.

Roof sheathing to be 1 x 12, s. 1 s., fir nailed with 8d nails and laid to allow for swell and shrinkage.

Roofing Paper.

Roofing paper to consist of one layer, one ply Cronolite sanded rubber roofing. Paper to be tacked with large head nails and well cemented. After paper has been laid put on one heavy coat of hot asphalt (3½ pounds to the square yard) over which spread as much hot gravel as will be held by the asphalt. After it has cooled remove the excess gravel.

Roofing Gravel.

Gravel to be furnished by contractor. All gravel rejected by a 3/32 inch screen and passing through a 5/16 inch screen to be termed roof gravel.

Gutters and Stairways.

There shall be one stair inside and one outside over embankment. Carry gutter as shown on plan 12 feet outside of embankment

Concreting.

General.

Inside slope, bottom, all piers, buttresses of swing pipe and base for sounding well, to be concrete reinforced with steel fabric.

Preparation.

All concrete to be prepared and mixed as herein specified.

Pipe Openings.

All pipe openings to be thickened and reinforced as shown on plans.

Piers.

For each post there shall be a pier 30 inches square and 12 inches deep. Tops of all piers to be in the same plane. Concrete to be poured in collapsible wooded forms so constructed as to hold fabric for floor in upper part of pier. Place ⅝-inch dowel pins in piers. Allow piers to set three days before setting posts.

Floor.

Floor to be of 3-inch concrete, reinforced with one layer of galvanized Clinton Electric Welded fabric 6-inch by 6-inch mesh and No. 6 B. W. G. wire each way. Reinforcing to be laid in straight lines and to lap at least one mesh. Joints to be securely wired. Reinforcement to be imbedded in center of slab and all stretched to lay flat. Reinforcing to pass through wooden form at the edge of the embankment and to extend up the sides. Concrete to be thickened at the foot of the embankment.

Drainage.

Bottom of reservoir to be sloped so as to drain towards the swing pipe pit.

Slope.

Sides are covered with 2½ inch slab of concrete, reinforced with one layer of reinforcing as hereinabove specified.

Concrete.

Concrete for floor to be one part Portland cement and 2½ parts sand and 1¾ parts of ⅝ inch gravel and 2¾ parts of 1½ inch gravel. Inner slope to be of one part Portland cement, 2½ parts sand, 2½ parts ⅝ inch gravel and 2 parts of 1 inch gravel.

Mixing and Pouring.

Mix in a Power Batch mixer. Use no more water than necessary to spread.

Pouring Floor.

First place the fabric upon the ground, pour over it 1½ inch concrete. Pull the fabric through this layer of concrete and allow it to rest upon the top. Before the concrete has been allowed to set, pour the second layer. After the second layer has been poured tamp with wooden puddlers and finish with a trowel.

Pouring Slope.

Pour 1¼ inch slab on slope, draw reinforcing and finish as above specified.

Joints.

At the end of each day's work, bevel and rough the ends of the concrete poured so that a bond may be obtained with the next day's pouring.

Grouting.

Fill all cracks that may appear during construction. After being allowed to set twenty days grout the entire surface with a cement wash.

Wetting.

During and after construction, keep the finished work well moistened.

Gravel and Sand.

Gravel to be treated in the following manner: Pit gravel to be passed through a revolving screen with ¼ inch mesh wire cloth, and ⅝ inch holes and 1½ inch, respectively. All gravel passing through ¼ inch holes to be termed selected sand. All rejected and passing through ⅝ inch screen to be termed ⅝ inch gravel. All rejected and passing through 1½ inch screen to be termed 1½ inch gravel. All rejected thereafter to be recrushed.

Cement.

Cement to be ———— Portland cement, taking approximately 12,300 sacks to the reservoir.

TANKS.

Steel tankage for oil storage are usually of the following dimensions:

Capacity	Diameter	Height
55,000 barrels	114 feet 6 inches	30 feet
37,000 barrels	94 feet 0 inches	30 feet
30,000 barrels	86 feet 0 inches	30 feet
20,000 barrels	70 feet 0 inches	30 feet
20,000 barrels	77 feet 0 inches	25 feet
10,000 barrels	49 feet 7 inches	30 feet
10,000 barrels	54 feet 0 inches	25 feet
5,000 barrels	43 feet 0 inches	20 feet

SPECIFICATIONS FOR HEAVY STEEL TANK.

There is considerable variation in specifications and cost. The following specifications represent probably the heaviest and most substantial construction of a 55,000 barrel tank with steel roof:

	Steel, thickness	Rivets, vertical seams	Rivets, horizontal seams
1st ring	9/16 inch	7/8 inch triple	3/4 inch single
2d ring	15/36 inch	3/4 inch triple	3/4 inch single
3d ring	11/32 inch	3/4 inch double	3/4 inch single
4th ring	5/16 inch	5/8 inch double	5/8 inch single
5th ring	1/4 inch	7/16 inch double	7/16 inch single
6th ring	7/32 inch	3/8 inch single	3/8 inch single
Bottom	1/4 inch		1/2 inch single

Top angles, 3½ x 3½ x ⅜, 7/16 inch rivets, single.
Bottom angles, 4 x 4 x ½, ¾ inch rivets, single.
Roof, ⅛ inch thick, 5/16 inch rivets, single.

Cost of such tanks, including grading and piping, is shown by a contract at Coalinga in 1913 to be $0.346 per barrel (20 tanks $380,000). Lighter tanks with wooden roof are more common and cost 23 cents to 25 cents per barrel, plus the foundation cost. Solid earth foundation is necessary to prevent seams from opening.

We are indebted to the Lacy Manufacturing Company and to the Lewellyn Iron Works, both of Los Angeles, for the following specifications, which are said to cover the average construction. Steel roofs are sometimes installed at refinery tanks, but wooden roofs are most frequently used in the fields.

There is frequently but little fire protection, as California fields are free from lightning which is a source of danger in other regions. However, some tanks are provided with steam pipes below the roof. The Standard Oil Company has a patented process which extinguishes fire by means of a chemically formed foam. The company offers the use of this system to other operators without charge and will furnish plans and specifications at cost. Such intelligent generosity is to be highly commended.

SPECIFICATIONS FOR STEEL OIL TANK.

(Capacity 37,000 barrels.)

Dimensions.

Ninety-five feet six inches (95′ 6″) diameter by twenty-eight feet no inches (28′ 0″) high.

Foundation.

Foundation to be graded and completed by the purchaser ready to receive the tank.

Material.

American Steel Manufacturers' Association Standard Specifications for tank steel. All material as to quality and dimensions subject to inspection and acceptancy by the purchaser at factory before shipment.

Thickness of Material and Riveting.

Description of part		Diameter of rivets		Rows of rivets	
Name	Dimensions	Seam, vertical	Seam, horizontal	Seam, vertical	Seam, horizontal
1st ring	16 pounds per sq. ft.	¾ inch	¾ inch	Double	Single
2d ring	14 pounds per sq. ft.	¾ inch	¾ inch	Double	Single
3d ring	12 pounds per sq. ft.	⅝ inch	⅝ inch	Double	Single
4th ring	10 pounds per sq. ft.	½ inch	½ inch	Double	Single
5th ring	8 pounds per sq. ft.	⅜ inch	⅜ inch	Double	Single
6th ring	8 pounds per sq. ft.	⅜ inch	⅜ inch	Single	Single

Bottom sketch plates No. 4 gauge, ⅜ inch rivets, single.
Bottom rectangular plates No. 6 gauge, ⅜ inch rivets, single.
Bottom angle, 4 inch x 4 inch x ½ inch, ¾ inch rivets, single.
Top angle, 3 inch x 3 inch x ⅜ inch, 7/16 inch rivets, single.

Both top and bottom angles to be spliced with heavy splice plates.

Rivets to be of the proper length to give best possible head and to be properly spaced so that the shearing stress per square inch on any rivet shall never exceed 13,000 pounds with the tank full of water.

Roof.

Roof to be supported by 6″ x 6″ posts, 4″ x 10″ beams, 2″ x 8″ rafters and sills and 1″ wood sheathing. The posts to be thoroughly braced with 1″ x 6″ braces. Roof covered and made water tight with prepared asphalt roofing to be approved by the purchaser. All posts to be securely bolted to the 4″ x 10″ beams.

Manhead.

Manhead in bottom ring to be 20″ diameter, made of ½″ plates with welded seam, and closed with a flat plate ½″ thick and ¾″ bolts.

Pipe Flanges.

Tank to be furnished with the following pressed steel flanges riveted to shell (as specified by purchaser).

Hatch.

Tank to have one hatch in roof 24″ long and 18″ wide complete with cover.

Iron Ladder.

Tank to have an iron ladder riveted to shell and running from ground to top of tank.

Painting.

The outside of tank to be painted with one good coat of asphalt paint.

Riveting.

All rivets over 7-16″ to be driven hot. All rivets to be driven on outside of tank, except bottom rivets.

Caulking.

All caulking on the sides to be done with a round nosed tool on the outside of tank. Bottom to be caulked on the inside.

Swing Pipes.

Tank to be equipped with one ten inch swing pipe and valve. Swing pipe to be operated by a windlass of wrought iron complete with the necessary cast iron gears, handle and wire rope located on roof of tank and connected to swing pipe.

Workmanship.

The work shall all be done in a good workmanlike manner and tanks guaranteed to be tight. Sheets in the bottom to be carefully punched by a multiple punching machine. Sheets in the sides to be properly curved and carefully punched, holes to match within 15 per cent of width of hole.

SPECIFICATIONS FOR STEEL OIL TANK.

(Capacity 55,000 barrels.)

Dimensions.

One hundred and fourteen feet six inches (114′ 6″) diameter by thirty (30′) high.

Thickness of Material and Riveting.

Description of part		Diameter of rivets		Rows of rivets	
Name	Dimensions	Vertical	Horizontal	Vertical	Horizontal
1st ring	23 pounds per sq. ft.	$\frac{7}{8}$ inch	$\frac{3}{4}$ inch	Triple	Single
2d ring	19 pounds per sq. ft.	$\frac{3}{4}$ inch	$\frac{3}{4}$ inch	Triple	Single
3d ring	14 pounds per sq. ft.	$\frac{3}{4}$ inch	$\frac{3}{4}$ inch	Double	Single
4th ring	12 pounds per sq. ft.	$\frac{5}{8}$ inch	$\frac{5}{8}$ inch	Double	Single
5th ring	10 pounds per sq. ft.	$\frac{3}{8}$ inch	$\frac{3}{8}$ inch	Single	Single
6th ring	8 pounds per sq. ft.	$\frac{3}{8}$ inch	$\frac{3}{8}$ inch	Single	Single

Bottom sketch plates No. 4 gauge, $\frac{3}{8}$ inch rivets, single.
Bottom rectangular plates No. 6 gauge, $\frac{3}{8}$ inch rivets, single.
Bottom angles, 4 inch x 4 inch x $\frac{1}{2}$ inch, $\frac{3}{4}$ inch rivets, single.
Top angles, $2\frac{1}{2}$ inch x $2\frac{1}{2}$ inch x 5/16 inch, 7/16 inch rivets, single.
Other items same as for 37,000 barrel tank.

Measurement or "strapping" of tanks is frequently done under the following system: Run steel tape around outside of tank immediately above the lowest row of rivets, also in the notch at the top of each ring, and immediately below top angle iron. Measure vertical distances between these points of measurement. Strapping should be done while tank is full owing to the slight expansion under pressure. Gauge sheets are computed from such measurements and show the capacity of the tank for each successive quarter (in some cases one eighth) of an inch.

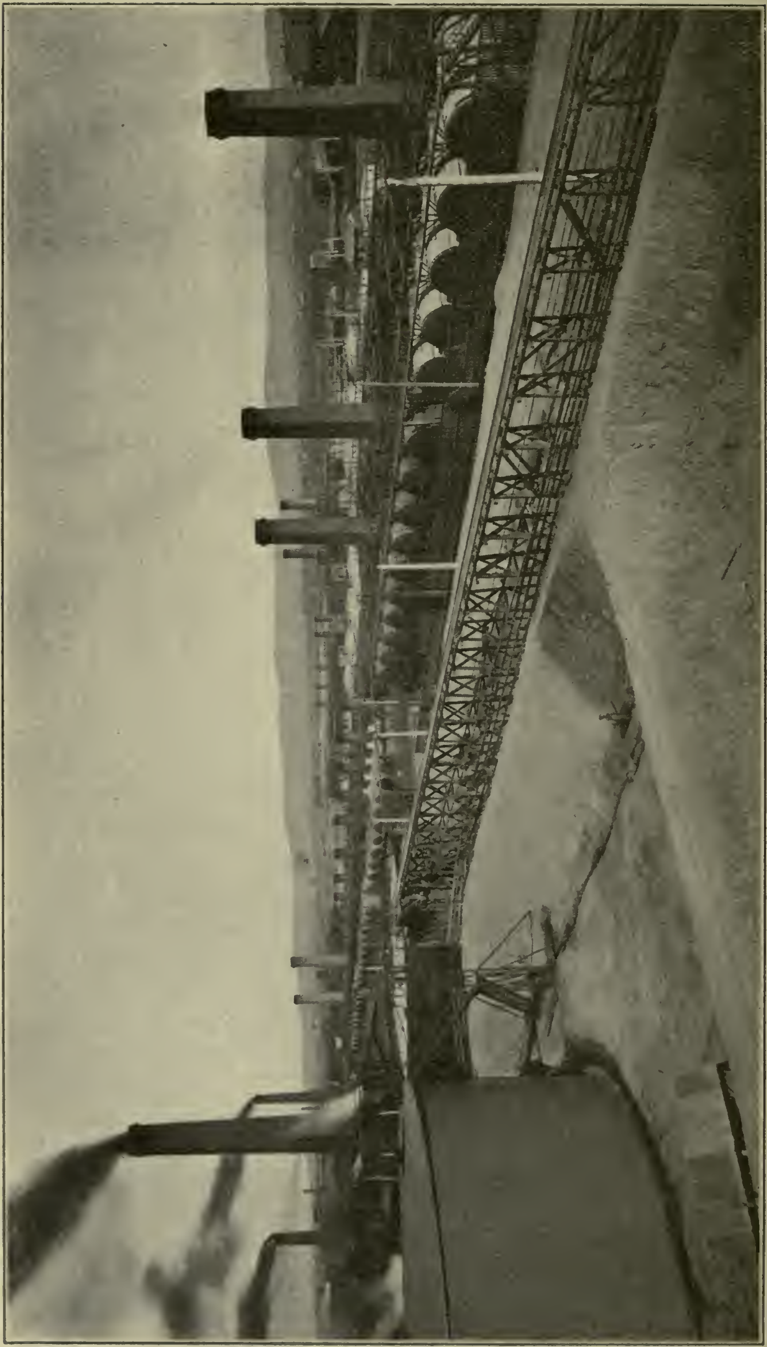
Oil is measured or "gauged" with a steel tape suspended from the top of the tank. A measurement is taken immediately before the valves are opened and immediately after closing. Two systems are used in measuring the oil, viz: from a point on the bottom of the tank to which the weighted tape is lowered, or from a point at the roof or top of the tank. Possibly the latter is more accurate.

Corrections of both gravity and amount are made, depending upon the temperature, 60° Fahrenheit being the standard. The correction for temperature is dealt with on page 79.

REFINING.

The magnitude of the refining business in California is shown by the accompanying list of plants. Much of this information was furnished by Mr. D. B. W. Alexander. It should be borne in mind that the figures of capacity are subject to considerable variation, depending upon how many steps of refining are carried on at the plant. Many of the plants do not run continuously on account of fluctuation in market conditions.

It is beyond the scope of this publication to attempt to describe in detail the various steps in refining. This very important subject has received but scant attention by writers using the English language, notwithstanding the fact that the United States refines more petroleum than any other country.



Refinery of Standard Oil Company at Richmond, California.

OIL REFINERIES AND TOPPING PLANTS.

(Dismantled or Removed.)

Name	Location	Date built	Capacity per month. Oil, barrels. Asphalt, tons	Stills		Remarks
				Number	Size (barrels)	
Berkeley Lubricating Oil Works	Berkeley	1881		1	50	Ventura seepage oils used.
Blankenhorn Refining Company	Bakersfield	1893				Lubricants from 25° Baume Sunset oil.
Buena Vista Petroleum Company	McKittrick	1864		1	70	Paving mixture from seepage and brea.
California Liquid Asphalt Company	Summerland	1902		Open	kettles	Asphalt.
California Liquid Asphalt Company	Summerland	1906	400 tons			Moved to Hadley, 1909.
California Petroleum and Asphalt Company	Carpenteria	1891				Later became Alcatraz Asphalt Company, then Columbia Oil, Asphalt and Refining Company.
California Star Oil Works	Newhall	1875		1 1 1	100 50 40	Distillates, closed 1883.
Clark, Johns & Co.	Ventura	1876				
Franklin Refining Company	Los Angeles	1897				
Gilbert, Geo. S.	Ventura	1861		6	10	Distillate and coke from seepage.
King Keystone Refining Company	Berkeley	1902				Moved—now Monarch Oil Refining Co.
Lellerman, Dr.	Camulos	1865				Experimental for Philadelphia and California Petroleum Company.
Pacific Coast Oil Company	Alameda	1880				Sold in 1902 to Standard—moved to Richmond.
Stott, Chas.	Santa Paula.					
Standard Asphalt Company	McKittrick	1892	500 tons	12	kettles	Asphalt.
Texas Oil and Refining Company	Los Angeles	1902	300 tons			Distillate and asphalt.

OIL REFINERIES AND TOPPING PLANTS.

(Operating or Capable of Operation.)

Name	Location	Date built	Capacity per month. Crude, barrels. Asphalt, tons	Stills		Products
				Number	Size (barrels)	
Adeline Oil Company	Maricopa	1910		2	150	Distillate, road oil.
American Oriental Oil Company	Martinez	1904	1,000 tons*			Distillate, asphalt.
American Petroleum Company	Fellows	1913		Contin	uous system.	
Amalgamated Oil Company	Los Angeles	1905	105,000 bbls.	3	300	Distillate, road oil.
Asphaltum Oil and Refining Company	Los Angeles		14,000 bbls.	1 2 2	200 150 50	Kerosene, distillate, stove oil, gasoline, asphalt.
Associated Oil Company	Gaviota	1899	150,000 bbls.	9 3	220 200	Fuel oil, gasoline, kerosene and distillate.
Associated Oil Company	Avon	1913	360,000 bbls.	8	500	Fuel oil, gasoline, distillate.
Atlas Refinery	Los Angeles	1900	30,000 bbls. 1,400 tons	2 1	300 265	Distillate, road oil.[1]
Barber Asphalt Paving Company	Los Angeles	1890	30,000 bbls. 1,400 tons	3 3	300 150	Distillate, asphalt, stove oil.
Beckett	Arroyo Grande.					
Buckeye Refining Company	Bakersfield	1901				Light oils.[2]
California Fresno Oil Company	Fresno	1882	100 tons*	4	75	Asphalt.
California Liquid Asphalt Company	Hadley	1909	1,000 tons* 13,000 bbls.	2 1	100 250	Distillate, kerosene, gasoline and asphalt.
California Oil and Asphalt Company	Los Angeles	1902	450 tons*	2	100	Distillate, asphalt.
Capitol Refining Company	Berkeley	1900	600 tons*			Distillate, asphalt.
Capitol Crude Oil Company	Santa Paula.					
Columbia Oil, Asphalt and Refining Company	Carpenteria	1905	450 tons*	2 1	150 250	Asphalt, distillate.
Continental Oil Company	Los Angeles	1907	600 tons*			Asphalt, distillate.
Cooper	San Diego.					
Densmore-Stabler Refining Company	Los Angeles	1902	20,000 bbls.	6	150	Distillate, gasoline, stove oil, asphalt, kerosene, lubricants.[3]
Eastern Consolidated Oil Company	Bakersfield	1904	1,000 tons*			Distillate, asphalt.
El Oso Asphalt Company			9,000 bbls.	1 1 1	235 160 30	Distillate, asphalt, gasolene.
Ensign-Baker Refining Company	Hadley	1910	1,000 tons			Distillate, asphalt.
General Petroleum Company	Vernon	1913	300,000 bbls.	Trumb	le plant	Gasoline, distillate, fuel oil.

General Petroleum Company	Mojave	1913	200,000 bbls.	Trumble plant		Gasoline, distillate, fuel oil.
General Petroleum Company	Kerto	1913	2,000 bbls.	Trumble plant		Gasoline, distillate.
Guaranty Oil Company	Los Angeles		30,000 bbls.	5	200	Gasoline, distillate, idle.
Hercules Oil Refining Company	Los Angeles	1900	30,000 bbls.	4 2 2	100 300 600	Distillate, asphalt, road oil, stove oil.[3]
Jordan Oil Company	Los Angeles	1900	9,000 bbls.	2 1	125 250	Distillate, kerosene, lubricants.
King Refining Company	Bakersfield	1901	500 tons			Distillate, asphalt.
Los Angeles Oil Refining Company	Olinda			Continuous system.		
Monarch Oil Refining Company	Berkeley	1910	600 tons			Distillate, asphalt.
More	Goleta.					
National Oil Refining and Manufacturing Company	Bakersfield	1904	1,200 tons			Distillate, asphalt.
Pacific Refining and Roofing Company	San Francisco	1903	300 tons			Roofing, asphalt.
Pacific States Refining Company	Fruitvale	1904	400 tons			Distillate, asphalt.
Paraffine Paint Company	South San Francisco	1900	100 tons	2 2	125 30	Paint and roofing asphalt.
Phoenix Refining and Manufacturing Company	Bakersfield	1902	1,200 tons			Distillate, asphalt.
Pinal-Dome Oil Company	Betteravia	1910	36,000 bbls.			Fuel oil, distillate, gasoline.
Pioneer Roll Paper Company	Los Angeles	1908	14,000 bbls. 600 tons	2	390	Roofing paper asphalt, distillate.
Producers Refining Company	Bakersfield	1903	700 tons.			
Producers and Refiners Oil Company	Oilport	1906	5,000 bbls.	15		Never operated.
Puente Oil Company	Chino	1896	30,000 bbls.	3 1 1 1	220 200 150 40	Distillate, fuel oil.
Standard Oil Company	Richmond	1902	1,950,000 bbls.	100 15 6	1,000 crude 250 asphalt 1,350 rerun	All classes of products.
Standard Oil Company	El Segundo	1911	450,000 bbls. 2,250 tons	20 3 3	1,000 crude 600 asphalt 1,350 rerun	Asphalt, gasoline, kerosene, benzine, fuel oil.
Standard Oil Company	Bakersfield	1912	300,000 bbls.	3 3	1,000 crude 600 road oil	Distillate, fuel oil.
Southern Refining Company	Los Angeles	1900	21,000 bbls.	2 2 1	250 100 50	Distillates, gasoline, asphalt, kerosene, stove oil, axle grease.
Sunset Oil and Refining Company	Ostend	1903	60,000 bbls.	16	150	Distillate, asphalt.

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*Asphalt.

[1] Leased to Union Oil Company.

[2] Leased to National Oil Refining and Manufacturing Company.

[3] Run by Turner Oil Company.

[4] Fairchild, Gilmore, Wilton Company.

OIL REFINERIES AND TOPPING PLANTS—Continued.

Operating or capable of operation.

Name	Location	Date built	Capacity per month. Crude, barrels. Asphalt, tons	Stills		Products
				Number	Size (barrels)	
Sunset Monarch Oil Company	Maricopa	1907	1,500 tons			Distillate, asphalt.
Union Oil Company	Oleum	1895	300,000 bbls. 4,500 tons	56	Continuous system	All classes of products.
Union Oil Company	Bakersfield	1903	3,000 tons	12	Continuous system	Distillates, asphalt, coal oil, fuel oil.
Union Oil Company	Fullerton	1911	210,000 bbls.	12	Continuous system	Gasoline, distillate, fuel oil.
Union Oil Company	Santa Paula	1912	20,000 bbls.	8	Dyer system	Gasoline, distillate, fuel.
Union Oil Company	Avila (Port San Luis)	1910	360,000 bbls.	12	Dyer system	Gasoline, distillate, fuel.
Volcan Oil Company	Bakersfield	1901	400 tons			Distillate, asphalt.
Warren Bros.	Rodeo	1903	800 tons			Asphalt, distillate.[5]
Warren Bros.	Bakersfield	1904	1,500 tons			Distillate, asphalt.[6]
Yosemite Oil Refining Company	Los Angeles	1902	450 tons	2	100	Distillate, asphalt.

[5] Leased from Western Oil Refining Company.
[6] Leased from California Kern Oil Company.

GASOLINE FROM NATURAL GAS.

The condensation of gasoline from natural gas has become an important adjunct to the oil business of California. The product enters the market under the name of "casing head gasoline" with a gravity of 75° to 85° B., and being very volatile, is usually mixed with one or two parts of heavier distillate before being retailed or consumed.

The Interstate Commerce Commission provides regulations as to the methods of testing and shipping liquified petroleum gas, depending upon the vapor pressure.

All gas does not yield gasoline equally under compression. A chemical analysis is of but slight value in estimating the possible yield. It is best to make an actual test with a small compressor and cooler. The richest gas is said to usually occur under some of the following conditions, viz: old pumping wells, light gravity oil and light rock pressure.

The simplicity of the procedure causes astonishment that it has so recently come into use. It is practically compression and refrigeration. Compressors are usually two stage, although sometimes three stage. Steam or gas engines usually furnish power at slight cost, as the gas is available as fuel after giving up its gasoline content. There are numerous variations of mechanical arrangements at the plants. The accompanying diagram, Fig. 6, represents the usage at a typical plant, having a Bessemer two-stage compressor 13½ x 16 x 6¾, 125 revolutions per minute. Capacity 240 cubic feet per minute (at 75 per cent efficiency), belted to Bessemer twin two-cycle gas engine, 110 horsepower, 180 revolutions per minute.

Many plants do not include the expansion engine, but its advantages are marked. It reduces the temperature considerably, making it possible to run at a much lower pressure than 250 pounds, which is difficult to handle, especially at stuffing boxes. Of course, some power is also available which would otherwise be wasted.

Pressure and temperature at different stages are about as follows in an ordinary run at the above mentioned plant:

Gas pressure:

Low pressure intake	0 pounds
Low pressure discharge	32 pounds
High pressure discharge	250 pounds
Final discharge	3 to 10 pounds

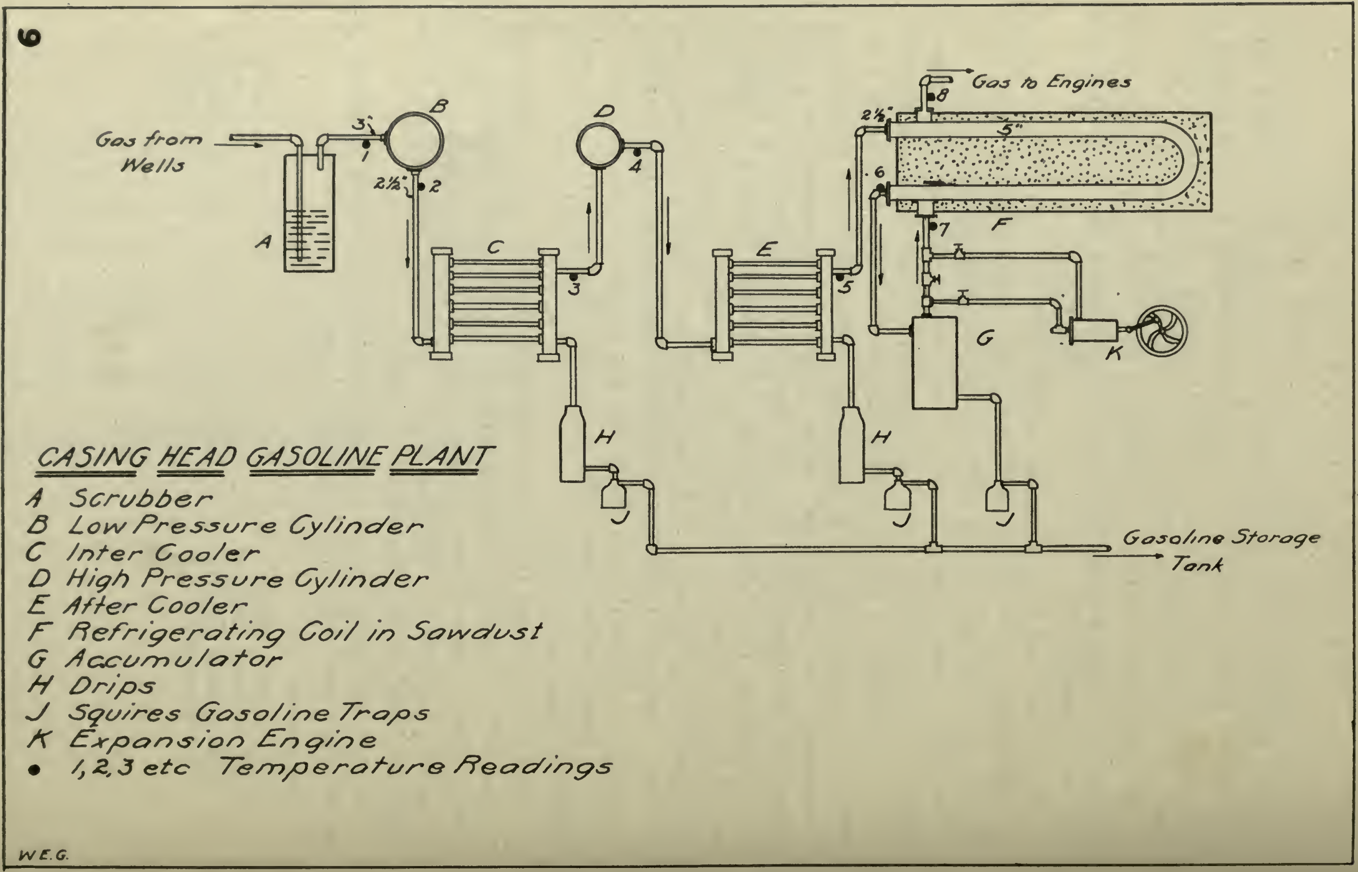


Fig. 6. Flow Sheet of Casing Head Gasoline Plant.

Gas temperature:

Low pressure intake	(1)	70° F.
Low pressure discharge	(2)	190° F.
High pressure intake	(3)	70° F.
High pressure discharge	(4)	190° F.
Aftercooler discharge	(5)	70° F.
Expansion, engine intake	(6)	50° F.
Expansion, engine discharge	(7)	+18 to —10° F.
Plant discharge	(8)	68° F.

Gasoline Production Per Hour.

Intercooler, gasoline	2½ gallons (70° B.)
Intercooler, water	½ gallon
Aftercooler, gasoline	35 gallons (93° B.)
Aftercooler, water	¼ gallon
Accumulator, gasoline	9 gallons (94° B.)

The following casing head gasoline plants are operating. The figures of capacity and yield are only approximations:

Name	Location	Cubic feet, 24 hours	Gallons per M.
Olinda Gasoline Company	Olinda	300,000	2½
Pacific Gasoline Company	Brea	2,500,000	1
Brea Gasoline Company	Brea	1,500,000	1
Hurley, Smith & Collins	Sherman	2,500,000	1
Standard Oil Company	Coyote	5,000,000	½
Standard Oil Company	Newhall	250,000	3 (?)
Gilmore Oil Company	Salt Lake	250,000	1
Montebello Oil Company	Fillmore	350,000	2½
Pinal-Dome Oil Company	Santa Maria	5,500,000	1
Columbia Oil Products Company	Puente	180,000	4
Union Oil Company (two plants)	Santa Maria	4,500,000	¾
American Gas Company	Santa Maria	1,000,000	1½
Rice Ranch Oil Company	Santa Maria	1,500,000	1
Purity Gasoline Company	Santa Maria	500,000	2
Hall & Hall	Santa Maria	300,000	1½
Turner Oil Company	Coalinga	1,000,000	2

Cost of construction, of course, varies, but is stated to have averaged about $25,000 to $30,000 per million cubic feet capacity.

Operating cost is not great, the amount of labor being about the same as is required for an ordinary compressor plant (see Kern River, page 214). The power costs practically nothing.

The manufacture of casing head gasoline has been a great factor in the reduction of retail prices of all sorts of gasoline.

GAS PRODUCTION OF VARIOUS COUNTIES.

The production of natural gas is a subject upon which it is difficult to gather accurate figures. The magnitude of the oil industry alone has prevented us from dealing with the natural gas industry as fully as could be desired.

The following figures are from records of the State Mining Bureau. The largest single gas field is at Midway, which is described on page 255.

San Joaquin County.

Year	Quantity	Value
1894		$75,000 00
1895		100,000 00
1896		85,157 00
1897		57,411 00
1898		57,289 00
1899	102,930 M. cubic feet	84,880 00
1900	27,612 M. cubic feet	19,862 00
1901		60,456 00
1902	81,481 M. cubic feet	67,868 00
1903	88,134 M. cubic feet	44,399 00
1904	100,437 M. cubic feet	47,635 00
1905	100,950 M. cubic feet	53,915 00
1906	103,450 M. cubic feet	55,115 00
1907	101,000 M. cubic feet	52,723 00
1908	60,903 M. cubic feet	49,194 00
1909	271,883 M. cubic feet	149,063 00
1910	313,392 M. cubic feet	159,451 00
1911		114,433 00
1912		145,166 00
1913	142,730 M. cubic feet	67,967 00

Santa Clara County.

1894	80,000 cubic feet	*$4,072 00
1895	800,000 cubic feet	*12,000 00
1896		1,300 00
1913	2,000 cubic feet	500 00

*Natural carbonic acid gas from a mine.

Santa Barbara County.

1897		$246 00
1898		135 00
1899	150 M. cubic feet	120 00
1900	1,203 M. cubic feet	2,966 00
1901		438 00
1902	937 M. cubic feet	375 00
1903	320 M. cubic feet	320 00
1904	3,000 M. cubic feet	1,500 00
1905		
1906	1,000 M. cubic feet	500 00
1907	600 M. cubic feet	300 00
1908	715,612 M. cubic feet	357,806 00
1909	768,000 M. cubic feet	394,621 00
1910	9,198,000 M. cubic feet	1,393,250 00
1911		100,386 00
1912		253,633 00
1913	5,096,300 M. cubic feet	254,815 00

Sacramento County.

Year	Quantity	Value
1898		$12,000 00
1899	12,000 M. cubic feet	10,000 00
1900	11,750 M. cubic feet	11,750 00
1901		
1902	38,550 M. cubic feet	31,200 00
1903	31,680 M. cubic feet	30,518 00
1904	39,200 M. cubic feet	39,200 00
1905	43,564 M. cubic feet	43,564 00
1906	60,225 M. cubic feet	52,874 00
1907	60,225 M. cubic feet	52,874 00
1908	55,000 M. cubic feet	55,000 00
1909	60,000 M. cubic feet	60,000 00
1910	49,203 M. cubic feet	49,203 00
1911		83,890 00
1912		96,000 00
1913	72,000 M. cubic feet	33,000 00

Los Angeles County.

1901		$1,500 00
1910	30,920 M. cubic feet	15,208 00
1911		15,208 00
1912		78,672 00
1913	1,287,794 M. cubic feet	77,578 00

Ventura County.

1904	1,800 M. cubic feet	$2,700 00
1905	3,831 M. cubic feet	5,000 00
1906	3,500 M. cubic feet	1,000 00
1907	1,825 M. cubic feet	2,278 00
1908	3,625 M. cubic feet	4,531 00
1909	1,721 M. cubic feet	2,151 00
1910	545 M. cubic feet	681 00
1911		2,958 00
1912		4,163 00
1913	62,200 M. cubic feet	6,220 00

Solano County.

1907	6,341 M. cubic feet	$6,584 00
1908	7,743 M. cubic feet	8,053 00
1909	7,538 M. cubic feet	7,538 00
1910	7,949 M. cubic feet	9,110 00
1911		8,593 00
1912		8,528 00
1913	6,319 M. cubic feet	7,306 00

Humboldt County.

1909	600 M. cubic feet	$300 00
1910	1,000 M. cubic feet	500 00
1911		150 00
1912		150 00
1913		150 00

Fresno County.

Year	Quantity	Value
1912		$21,380 00
1913	236,100 M. cubic feet	23,610 00

Kern County.

1909	38,000 M. cubic feet	$2,714 00
1910	975,724 M. cubic feet	47,364 00
1911		165,438 00
1912		325,484 00
1913	7,111,237 M. cubic feet	568,899 00

Kings County.

1909	360 M. cubic feet	$360 00
1911		800 00
1912		1,650 00
1913	1,916 M. cubic feet	575 00

Tulare County.

1909	365 M. cubic feet	$185 00
1910	2,000 M. cubic feet	1,000 00

Orange County.

1912		$5,250 00
1913	192,240 M. cubic feet	9,612 00

CHAPTER IV.

COALINGA DISTRICT.

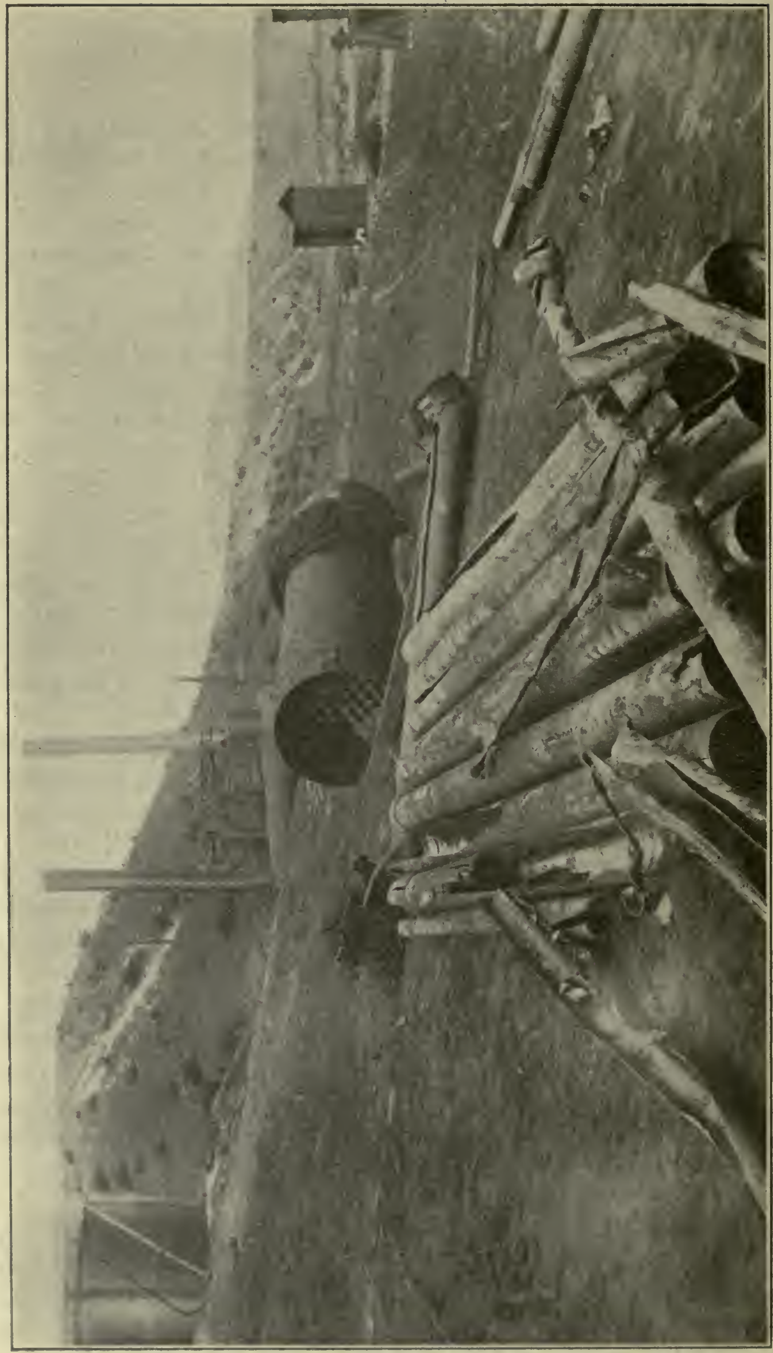
LOCATION.

The developed portion of the Coalinga district (see plate VII) is situated in the western part of Fresno County; some of the adjoining territory is in the western part of Kings County. All together it forms a long strip of territory extending from 119° 15′ west longitude and 35° 47′ north latitude at its southeast end to 120° 37′ west longitude and 36° 21′ north latitude at its northwest end, along the foot of the Mount Diablo range. The district is roughly 50 miles long and 15 miles wide, and covers about 700 square miles, taking in the foothill belt along the valley and extending westward to the summits of the first surrounding mountain ridges. Its northwest and southwest corners reach the crest of the Mount Diablo range. The proved area is about 14 miles long and 2½ miles wide.

Coalinga is situated in Pleasant Valley and is the principal town of the region. It is in the southern part of the developed oil territory and connected, by the Southern Pacific railroad, to the main San Joaquin Valley line. Alcalde is the terminus of the branch railroad to Coalinga and is represented only by one ranch house. Oilfields is a post office located eight miles northeast of Coalinga, in the East Side field. Coalinga is accessible from the west by four roads as follows: one over the Benito Pass at the head of Los Gatos Creek, one over the divide between Priest Valley and the head of Warthan Creek, one across the range between Stone Canyon and Warthan Creek, and one over Cottonwood Pass, down Avenal Creek and McLure Valley.

The climate of the region is arid and the precipitation almost all comes between the months of November and March. Cloudbursts rarely occur in the summer months, but otherwise this season is dry and the country becomes desiccated. Considerable of an underground flow of water is found in the stream channels from the Mt. Diablo range. Water is obtainable in wells over most of the district but it is usually highly charged with salts, from the late Miocene sedimentaries, and poor for drinking or boiler purposes. Drinking water is usually shipped from farther east in the San Joaquin Valley or is distilled in the boilers at the oil pumping stations. Drinking water for the town is supplied by a distilling plant and system of pipes.

The vegetation is sparse, the plains and lower hills being treeless and overgrown with sagebrush and other shrubbery. The low valleys are usually dotted with cottonwood trees, while the higher hills and valleys have a scanty growth of juniper and oak trees. The highest mountain slopes are mantled with pine, juniper, oak trees and chaparral. The character of the rocks exerts a marked influence on the vegetation, and formations may often be traced by the abundance or sparseness or character of the plants.



Casing worn out by sand carried with oil flowing from a gushing well. (Courtesy Standard Oil Co.)

HISTORY OF DEVELOPMENT AND RATE OF PRODUCTION.

The data concerning the early development and geology in the Coalinga district is taken from accounts given by W. L. Watts in Bulletins 3 and 19 of the California State Mining Bureau, and by Arnold and Anderson in Bulletin 398 of the U. S. Geological Survey. The geologic information already published, particularly in the latter publication, is so thorough that no further public work is necessary for economic purposes.

The history will be taken up by fields as follows: (1) The Oil City Field, lying in Oil Canyon near the north end of the district; (2) The East Side Field embracing the territory northeast of Oil Canyon and including Anticline Ridge; (3) The West Side Field extending southwestward from Oil Canyon as far as Alcalde Canyon; (4) The Kreyenhagen Field, which includes the Jacalitos and Kreyenhagen hills, Reef Ridge, and the territory southward to the Kings County and Kern County boundary; and (5) the region of the Kettleman Hills extending from the Guijarral Hills southward to the gap separating the Kettleman Hills from the Lost Hills.

The Oil City Field.

Attention was first called to the possibilities of oil existing in the Coalinga region by the occurrence of an oil seepage in the southwest corner of Sec. 17, T. 19 S., R. 15 E., just northwest of Oil City which was the center of the first drilling activity. Considerable light oil of a greenish color was collected in pits from the Cretaceous shales, and refined on a small scale. Although the oil was believed to have its source in underlying sands, nothing was known of their extent, or stratigraphic position.

The first successful development work was in 1890 when the Coast Range Oil Company, of Los Angeles, sunk a 163 foot well in Chico shale in the northern part of Sec. 20, T. 19 S., R. 15 E., from which gas and a little greenish oil of light specific gravity is said to have flowed. A windmill pump was attached to the well and ten barrels of oil pumped from it daily for two days, after which the production fell gradually.

During 1891–92 four wells were drilled in this same vicinity by Messrs. Rowland and Lacy, of Los Angeles, but only one of these was successful. It was 400 feet deep and yielded nine barrels of oil daily.

In 1895 the Producers and Consumers Oil Company of Selma drilled two wells a short distance southeast of the wells of Rowland and Lacy, which yielded fifteen or twenty barrels of 34° Baumé oil per day. The following year the property was taken over by Chanslor and Canfield who drilled a well 300 feet east of the old one in the NW. ¼, Sec. 20, and struck oil sand at 890 feet, which yielded 300 barrels of oil per day. This was the first big well of the district.

In 1897 the Clear Field Oil Company drilled a 1,100-foot well in the southeast corner of Sec. 18, T. 19 S., R. 15 E. Only a trace of oil was found. The same year the Home Oil Company of Selma, drilled a 1,400-foot well (The Blue Goose) farther east and farther down the dip of the strata. It is said to have flowed 500 to 1,000 barrels of oil per day and to have maintained a flow of 250 barrels per day as late as August, 1900.

Several other companies commenced operations in the Oil City Fields in 1899 but with indifferent success, or failure.

At present the producing wells are all in the north half of Sec. 20, T. 19 S., R. 15 E. They are pumped by jacks and no new wells are being drilled. The high grade of oil justifies operating the wells for the small amount produced. The limits of this pool of high gravity oil seem to have been pretty definitely established by drilling.

The East Side Field.

Development of this field began in 1900 with drilling operations of the Independence, Oil City Petroleum, Twenty-eight, Caribou, and other companies. In 1902 the California Oil Fields (Limited) entered the field and drilled in Secs. 21 and 27, T. 19 S., R. 15 E. In 1906-7, Mr. W. P. Kerr and associates, carried on operations in the northern part of Sec. 34, T. 19 S., R. 15 E. These wells were among the most productive in the district and have been absorbed, together with most of the other independent wells, except those in Sec. 22, by the California Oil Fields (Limited) or by the Standard Oil Company. In 1908 the completion of the T. C. Oil Company's well in Sec. 2, T. 19 S., R. 15 E., extended the proved territory two miles farther northward. In recent years the proved territory has been extended northward into sections 2 and 3 and southward into the NW. ¼ of Sec. 12 (see map).

Operations of the Imperial Oil Company in Sec. 2 were not successful, but recent developments and geologic study, particularly by Mr. M. J. Kirwan, County Oil Well Commissioner, suggest that some wells passed through oil sands without recognizing them. Therefore, the northern limit of the field is not definitely established. Developments will probably not extend much south of the Mohawk in Sec. 12 on account of the great depth.

The West Side Field.

Successful development work was begun in the north end of the West Side Field in 1901, when the Mercantile Crude, Commercial, Call, Maine State, and other companies started drilling. Exploitation was gradually carried southward until the region as far as the Esperanza lease in the SW. ¼ Sec. 6, T. 20 S., R. 15 E., was proved. The unsuccessful Blue Diamond well in the NE. ¼ Sec. 26, T. 20 S., R. 14 E., was also put down about this time, and tended to discourage development in the southern part of the field. Some development work was done in 1902 but the decline in the price of oil was at this time showing its effect on the dovelopment. In the fall of 1906 the Lucille well was brought in as a strong producer which proved the south end of the field, and encouraged development in the whole Coalinga district. In 1908 about one hundred wells were drilled simultaneously in the district. This year and that following saw the development of a series of exceptionally productive wells drilled along the eastern edge of the West Side Field by the American Petroleum Company. The Nevada Petroleum Company drilled farther east and proved the productiveness in that region. In September, 1909, the Silver Tip No. 1, in Sec. 6, T. 21 S., R. 15 E., came in as a gusher producing 20,000 barrels per day, and drew the attention of operators to the south end of the field where rapid development went on in Sec. 12, T. 21 S., R. 14 E., and Sec. 18, T. 21 S., R. 15 E., but neither of the regions have proved productive.

Future development may extend the proved territory some distance eastward until limited by depth or edge water. Southern and western extensions may add some slight production (see page 125).

The Associated Oil Company and Canadian Coalinga have proved part of the territory in Secs. 7 and 8, T. 21 S., R. 15 E., by developing producing wells. Developments south of T. 20 S., have been somewhat disappointing, many dry holes having been drilled. Several wells of exceptionally high gravity oil (22°–26°) have however been "brought in."

Several deep wells have been drilled south of Waltham Creek in the Jacalitos Hills without developing a producing property. This portion of the field has not a promising future.

West of the main field, Sec. 2, T. 21 S., R. 14 E., a number of shallow wells have been drilled during the past two years, which yield oil of from 15° to 21° B.

The Kreyenhagen Field.

In 1900 several prospect holes were drilled in the Kreyenhagen and Kettleman fields but no developments of consequence took place. Since 1907 more or less activity has been displayed in the region south of Waltham Creek, and such wells as the Golden Crest Esperanza Land and Oil Company, and El Cerrito have attempted to obtain oil from the formations overlying the Santa Margarita but so far without success.

Possibilities in the Kreyenhagen Field are limited to a narrow strip of steep dipping beds which will probably not furnish paying properties until the price of oil is a great deal higher than at present.

Some of the wells mentioned in this portion of the field illustrate a case where definite geologic predictions can be made. Useless expenditure would in this case have been prevented by following geological advice.

Kettleman Hills.

This locality illustrates a case where definite geologic predictions can not be made. The principal structural feature is an anticline, at the crest of which the Etchegoin formation is exposed. There are three unknown factors, namely, thickness of beds, above those in which oil might be expected; texture of the lower beds; and whether or not oil is contained in any of the lower beds. The most promising feature is the anticlinal structure. Several of the wells have been drilled without producing oil. They are as follows:

Coalinga Kettleman	NW. ¼ Sec. 2, T. 21 S., R. 17 E.	depth 4,700 feet
Medallion	NE. ¼ Sec. 20, T. 22 S., R. 18 E.	depth 4,165 feet
California Counties	N. ½ Sec. 4, T. 24 S., R. 19 E.	depth 4,030 feet
Coalinga Lakeview	NE. ¼ Sec. 26, T. 21 S., R. 17 E.	depth 3,250 feet
Baird	Center Sec. 24, T. 22 S., R. 18 E.	depth 3,400 feet

Statistics.—The total production from Fresno County (in which Coalinga is the only productive field) and average price are shown by the following table compiled from annual reports of the State Mining Bureau.

STATISTICS.

Fresno County.

Year	Barrels	Price per barrel
1896	14,119	$4 01
1897	70,140	1 01
1898	154,000	1 00
1899	439,372	1 00
1900	547,930	1 00
1901	525,433	45
1902	571,233	35
1903	2,214,160	33
1904	5,114,958	30
1905	8,890,000	27
1906	8,402,000	24
1907	9,050,300	40
1908	10,725,389	55
1909	15,406,619	60
1910	18,651,470	50
1911	19,499,611	48
1912	19,510,932	44
1913	18,656,965	43
Total	138,444,661	

Summary.

The history of development of the Coalinga Field and rate of production is best illustrated by the accompanying diagram (Fig. 7), which is partly constructed from the figures furnished by the Standard Oil Company

1904 to 1907.—During this period the number of producing wells gives an idea of the activity in the field. It will be noted that from the early part of 1904, when there were ninety-five producing wells, until the end of 1907, the increase was fairly regular at the rate of forty-four wells per year and that the total production quickly increased until the middle of 1905, when the regular increase in number of wells simply maintained the production at about 800,000 barrels per month.

1908 to 1910.—This period was remarkable for the increased activity, due to rise in price of oil, from less than thirty cents to over fifty cents (page 124) and new producing wells were drilled at the rate of 149 per year, which increased the monthly production to about 1,600,000 barrels per month.

1911 to 1913.—Shows fluctuation in activity but with the rate of production fairly well maintained.

The most remarkable and vital fact shown by the diagram is the regular rate of decline in production per well, since 1906. From an average of about one hundred barrels per well per day it has gradually fallen to about fifty-five, or at the rate of about six and one fourth barrels per year. The 1914 figures are not greatly different although they hint at a slower decline, but this may be due to inactivity of production.

Future rate of production is of course indefinite, owing to the many unknown factors, particularly price of oil, water trouble and cost of production. However, to illustrate the usefulness of the figures, some predictions may be justified. The number of wells can probably be economically increased to twice the present number. At present there are about twenty-two square miles of proved land, which with 915 wells allows 15.4 acres per well. At the rate of 149 new producing wells per year this drilling campaign would require six years. At the end of the six years the production per well per day would probably have fallen almost as low as eighteen barrels, giving a total monthly production of about one million barrels. It is believed that these estimates are very conservative, the wells may decrease more slowly than here indicated and the total number of wells may be greater. Further extension of the prediction is possibly not warranted by the general nature of the case, but some such study of the figures should certainly commend itself to the careful investor and illustrate the value of the statistics.

The total production of the field to date has been about 138,444,661 barrels, or 9,840 barrels per acre of the entire proved area, some of which has been only slightly depleted. The ultimate production from the proved area may reasonably be expected to increase these figures, at the very least, 50 to 65 per cent.

That these figures are extremely conservative is indicated by the fact that other estimates have been ten times as large.* (U. S. Geological Survey, Bulletin 398, p. 247.) Should the proved area be extended one half mile to the eastward along the entire field an addition of about six square miles would be made and an increase of 25 per cent over the above indicated ultimate production. Data are not at hand upon which to base a definite statement as to the probability of such extension, but the possibility must not be overlooked. Much depends upon the proper handling of the water problem.

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*See page 14.

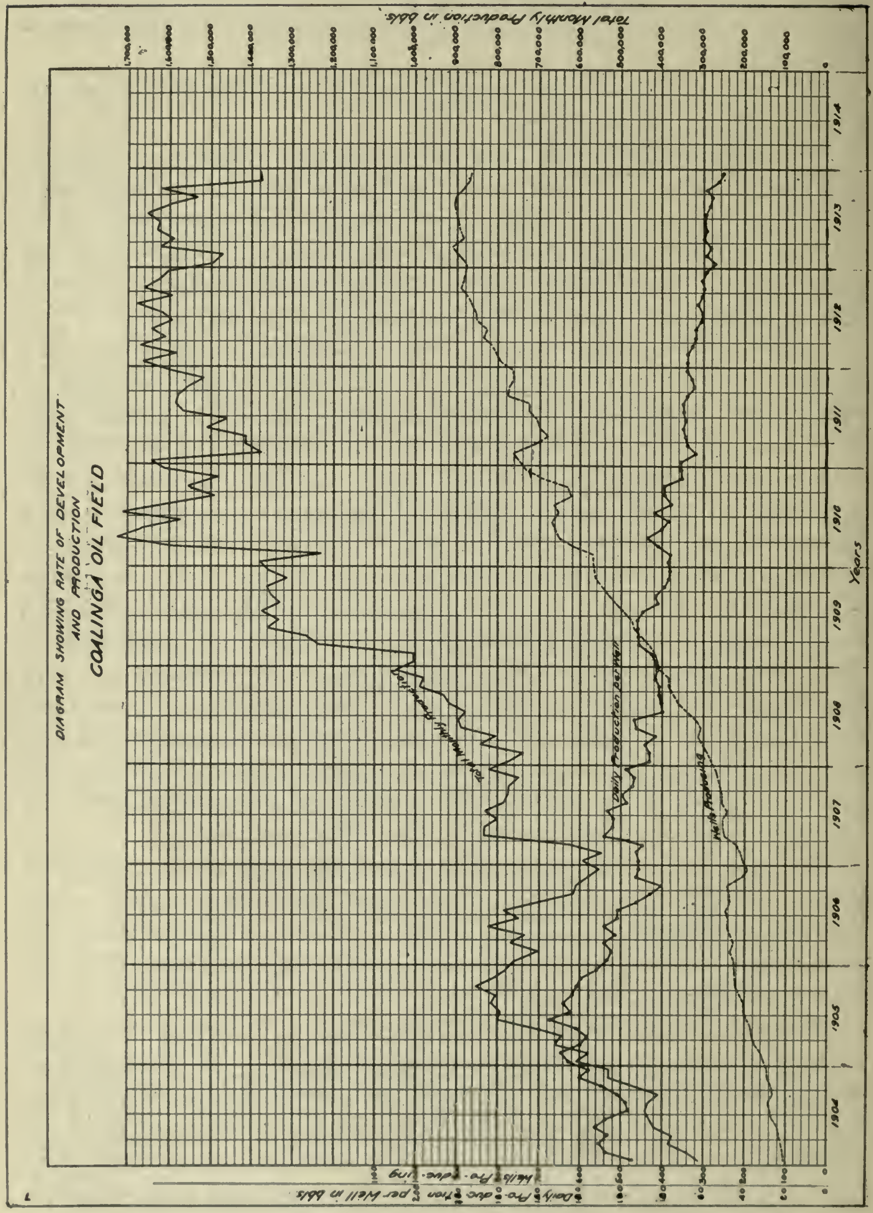


DIAGRAM SHOWING RATE OF DEVELOPMENT
AND PRODUCTION
COALINGA OIL FIELD
Total Monthly Production in bbls.
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
Years
Total Monthly Production
Daily Production per Well
Wells Producing
Wells Pro-duc-ing
Daily Pro-duc-tion per Well in bbls.
0
100
200
300
400
500
600
20
40
60
80
100

Fig. 7.

STATISTICS OF FIELD DEVELOPMENT.

(STANDARD OIL COMPANY.)

Coalinga.

Year	Wells producing	Number of wells completed during month	Monthly production	Barrels per well per day
1904.				
January	106	4	313,500	95
February	109	7	342,500	108
March	113	7	388,400	111
April	118	4	377,500	107
May	120	10	421,400	113
June	133	5	431,250	108
July	139	5	441,700	97
August	144	2	435,800	98
September	134	2	410,954	102
October	138	5	471,087	110
November	147	5	532,167	120
December	147	9	531,595	116
Total	------------	65	5,097,853	
1905.				
January	156	7	610,694	126
February	161	12	580,250	129
March	178	5	661,457	120
April	184	6	646,538	117
May	187	10	708,843	122
June	198	6	803,682	135
July	205	6	795,835	125
August	206	11	819,566	128
September	218	7	808,852	124
October	225	2	851,199	122
November	225	1	811,684	120
December	226	4	783,525	112
Total	------------	77	8,882,125	
1906.				
January	229	6	762,872	107
February	238	2	703,568	105
March	230	9	770,082	108
April	238	8	735,580	103
May	246	3	825,177	108
June	243	7	749,648	102
July	250	2	789,386	102
August	239	3	691,264	93
September	240	4	618,931	86
October	244	3	612,634	81
November	210	3	585,093	93
December	196	2	556,870	92
Total	------------	52	8,401,105	
1907.				
January	208	1	594,061	92
February	212	3	550,079	93
March	225	2	629,527	90
April	251	2	835,936	111
May	255	4	834,460	105
June	257	5	802,713	104
July	246	8	832,039	109
August	259	1	788,349	98
September	259	2	777,576	100
October	262	5	774,613	95
November	267	5	752,213	94
December	272	6	824,702	98
Total	------------	44	8,996,268	

STATISTICS OF FIELD DEVELOPMENT—Continued.

(STANDARD OIL COMPANY.)

Coalinga.

Year	Wells producing	Number of wells completed during month	Monthly production	Barrels per well per day
1908.				
January	286	15	776,386	87
February	294	8	739,245	87
March	306	11	847,074	89
April	319	11	807,876	84
May	310	8	891,264	93
June	320	17	899,193	94
July	344	19	881,012	80
August	365	12	922,176	81
September	378	11	934,042	82
October	389	14	992,809	82
November	388	14	981,802	84
December	409	12	1,052,916	83
Total		152	10,725,795	
1909.				
January	415	17	1,088,051	84
February	420	14	1,008,648	86
March	435	15	1,238,911	92
April	455	7	1,266,074	92
May	473	18	1,363,252	93
June	479	17	1,334,806	93
July	495	16	1,379,983	90
August	517	13	1,331,162	83
September	535	12	1,353,573	84
October	548	16	1,365,144	80
November	564	10	1,316,277	78
December	569	15	1,361,338	77
Total		170	15,406,619	
1910.				
January	572	21	1,380,630	78
February	573	34	1,231,161	77
March	624	24	1,603,902	83
April	654	24	1,730,452	88
May	667	7	1,669,283	81
June	671	18	1,572,913	78
July	657	23	1,714,669	84
August	669	20	1,612,891	78
September	626	11	1,490,203	79
October	632	10	1,550,735	79
November	693	12	1,482,411	71
December	733	14	1,612,220	71
Total		218	18,651,470	
1911.				
January	749	12	1,642,180	71
February	762	14	1,374,599	64
March	716	16	1,513,173	68
April	679	9	1,411,781	69
May	699	11	1,509,787	70
June	704	9	1,458,980	69
July	725	11	1,569,100	70
August	724	14	1,583,884	70
September	779	13	1,578,930	68
October	775	11	1,553,735	65
November	762	15	1,516,867	66
December	763	4	1,598,235	68
Total		139	18,311,251	

STATISTICS OF FIELD DEVELOPMENT—Continued.

(STANDARD OIL COMPANY.)

Coalinga.

Year	Wells producing	Number of wells completed during month	Monthly production	Barrels per well per day
1912.				
January	794	17	1,663,397	68
February	805	10	1,582,410	68
March	816	7	1,670,005	66
April	837	10	1,610,498	64
May	829	10	1,643,832	64
June	852	7	1,593,668	62
July	855	11	1,617,156	61
August	864	7	1,679,318	63
September	876	10	1,593,674	61
October	892	5	1,662,174	60
November	884	7	1,623,869	61
December	880	6	1,606,121	59
Total	------------	107	19,546,122	
1913.				
January	880	8	1,496,033	55
February	899	8	1,471,328	59
March	914	8	1,622,059	57
April	886	2	1,589,334	60
May	895	5	1,632,646	59
June	898	7	1,623,551	60
July	902	4	1,654,470	59
August	909	2	1,604,561	57
September	907	7	1,531,694	56
October	886	5	1,620,023	59
November	870	4	1,378,268	53
December	867	4	1,380,659	51
Total	------------	64	18,604,626	
Total completed	------------	1,086		
Idle or abandoned	------------	325		
1914.				
January	867	4	1,380,647	51
February	883	3	1,225,224	50
March	846	------------	1,378,880	53
April	844	4	1,310,340	52
May	856	2	1,351,972	51
June	859	3	1,324,740	51
July	878	5	1,396,798	51
August	887	5	1,396,767	51
September	871	2	1,358,580	52
October	834	------------	1,367,007	53
November	------------	------------	------------	------------
December	------------	------------	------------	------------
Total	------------	------------	------------	------------

FINANCIAL RESULTS.

Financial results in the Coalinga Field during the year 1913, as shown by 59 companies, producing 11,681,164 barrels of oil from 590 wells, are summarized as follows:

Capital. This figure can not be definitely determined, particularly the second item (property value) and any error here is apt to be on the side of an overstatement.

Cash paid for stock	$8,087,785 00
Property paid for stock	9,634,512 00
Total	$17,722,297 00

Dividends are difficult to determine, as many concerns are close corporations, making no public reports, hence our figures may be slightly below the actual amounts. Earlier records than 1909 were not available.

1909—17 companies	$1,287,244 00
1910—16 companies	1,366,243 00
1911—14 companies	1,236,338 00
1912—15 companies	1,154,328 00
1913—17 companies	956,098 00
Total	$6,000,251 00

Eight companies have regularly paid dividends for the five years (1909-1913) and the conditions under which they operated in 1913 may be summarized as follows: One merely received royalty. Their total number of wells is 224, producing about 5,480,000 barrels of oil, 29 per cent of the field total. Only one produces oil lower than 19° B. The average price was about 47 cents. Their dividends aggregated $647,042, or about 68 per cent of the total. Their average operating expense per well per day was $10.30, or 15.3 cents per barrel, including everything except the fixed charges, such as taxes, insurance and depreciation.

Production of all companies paying dividends in 1913 was about 8,580,000 barrels, or 46 per cent of the field total.

Other facts of interest along this line are shown in the table on page 10.

GEOLOGIC SUMMARY.

Franciscian formation.

The Franciscian formation is not exposed in the immediate neighborhood of the Coalinga oil fields. It is the oldest series of sediments in the district and is typically exposed in the northern part of T. 19 S., R. 13 E., where it is overlain by Cretaceous rocks. It is characterized chiefly in this region by hard, gray sandstone, of medium coarseness which has a flaky texture, due to crushing and elongation of the grains. Associated with these beds are small patches of bluish glaucophane-bearing and micaceous schists. Intrusions of serpentine are very characteristic. Farther north cherts, jaspers and conglomerates are also common in the series. The whole formation is almost completely metamorphosed and altered and forms very rugged topography, which can be distinguished for considerable distance. The series has in no place been found oil bearing and the metamorphism to which it has been subjected, would have permitted little if any oil to remain had the series ever contained oil.

Cretaceous rocks.

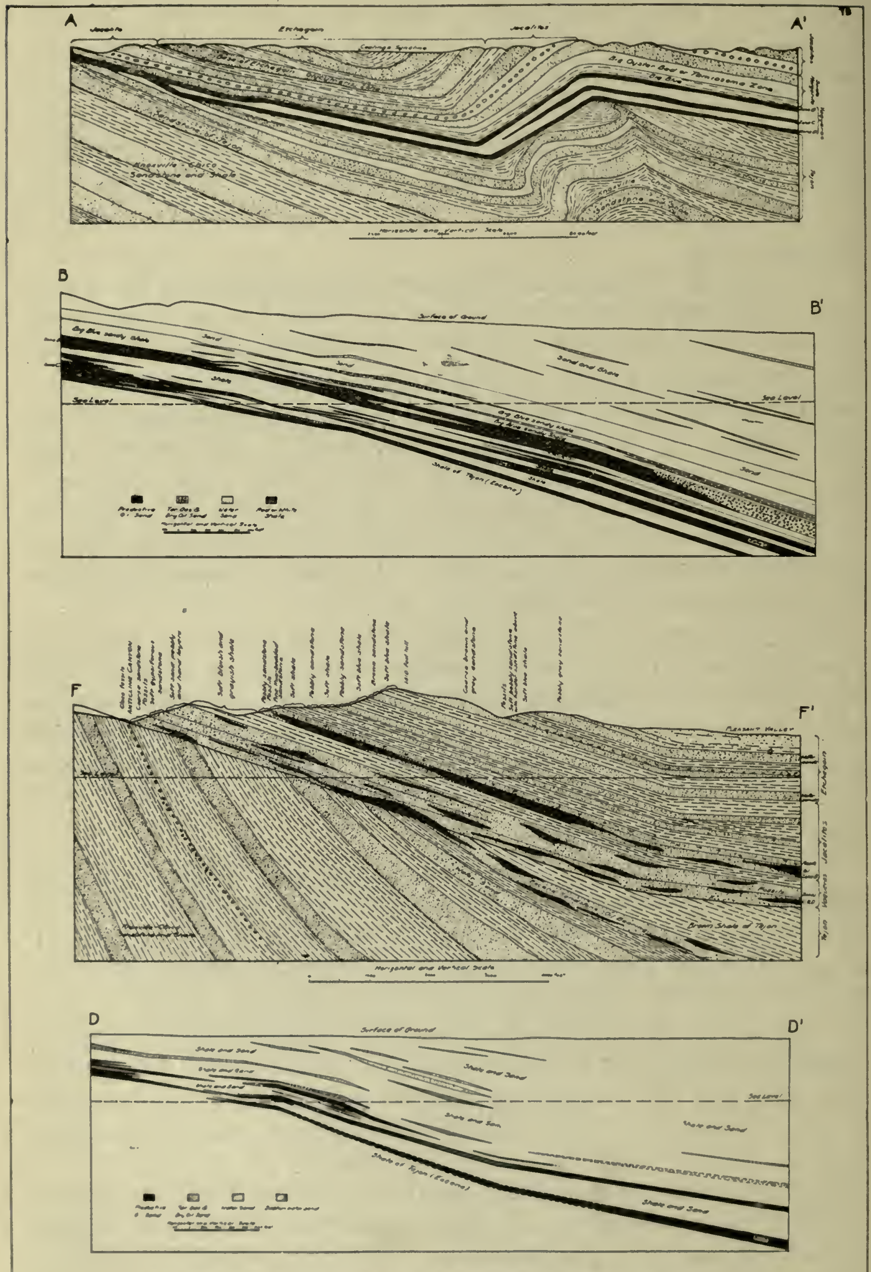
Overlying the Franciscian formation unconformably in the northwestern and southwestern parts of the district is a series of sandstone, shale and conglomerate of Cretaceous age. These are folded or tilted along an axis with a general direction of north 45° west, as is the prevailing structure of the whole district. The shales and sandstone of the lower portion are of a dark color, thinly bedded and compact, while the sandstones of the upper portion are of a drab color and concretionary. The strata represent some of the Knoxville as well as the Chico periods of time. Insufficient fossil and stratigraphic evidence have been obtained to separate them. The total thickness of the series has been estimated at over 12,000 feet.

The uppermost or purple shale member of the series is of particular interest, because it is probably the source of the light oil produced from the Oil City field, while its sandy zones probably furnish reservoirs for oil accumulation. This part of the formation is at least 1,200 feet thick and consists principally of foraminiferal shales. No oil has been obtained below this member.

Tejon formation (Eocene).

The Tejon formation, or middle Eocene, consists of sedimentary strata which overlie unconformably the Cretaceous series and dip towards the San Joaquin Valley. They form a discontinuous belt from one half to one mile wide, along the southeast slope of the northern Cretaceous area and along Reef Ridge. The beds have a thickness of 1,600 to 1,850 feet and may be divided into approximately equal portions, a lower one consisting of sandstone in the southern part of the district and of dark clay, shale and sand in the northern part, and an upper one consisting of white, siliceous, thinly bedded diatomaceous and foraminiferal shale.

The upper diatomaceous shale member is thought to be the original source of the petroleum found in the Tejon formation of the Coalinga district. It may have furnished some of the oil now found in the later formations. This shale is petroliferous practically throughout its extent in the district. The post-Eocene beds are petroliferous only when



HYPOTHETICAL GEOLOGICAL CROSS SECTIONS OF COALINGA OIL FIELD

(AFTER BULLETIN No 398 U.S.G.S.)

Fig. 7B.

associated with the Tejon, from which it is thought the oil migrated and collected in the more suitable reservoirs afforded by the Miocene beds.

Vaqueros formation.

The Vaqueros formation in the Coalinga district consists of a belt of hard and soft varicolored sandstone, shale, and conglomerate from 550 to 900 feet thick overlying unconformably the Tejon formation. The upper part of this succession has been formerly described as the Temblor formation.* The name Vaqueros has been extended in the Temblor range to include an older horizon† typically represented in the western Coast Range. The name as used in the Coalinga district includes only beds properly belonging with the Monterey series.

The "reef bed" is a hard ten-foot stratum of sandstone near the center of the formation. The top of the Vaqueros is limited by the "Big Blue," a zone of shales which is included in the overlying Santa Margarita formation.

The beds at the base of the Vaqueros are the chief oil sands of the district. The oil probably enters the sands from the underlying Tejon shales and collects under the overlying shales.

Santa Margarita formation.

The Santa Margarita formation is exposed in a strip along Reef Ridge and also in the East Side field. In the East Side field it consists of a basal member of about 300 feet of light-gray fine sand and clay that have a light bluish tinge when moistened. This member is overlain by the *Tamiosoma* zone, which comprises a thickness of about 175 feet of fossiliferous, fine, medium-grained, and coarse, usually gray sand and minor amounts of conglomerate. This in turn is overlain by 400 to 500 feet of unfossiliferous alternating beds of fine sand, sandy clay, coarser sand and gravel up to the base of the prominent and thick gravel zone considered as marking the base of the Jacalitos. Along Reef Ridge the formation consists almost entirely of siliceous and diatomaceous shales which overlap the Vaqueros and Tejon and grade conformably into the overlying Jacalitos formation.

This formation is an excellent horizon marker in the East Side field where the oil is found just below the "Big Blue." Oil in commercial quantities has not been found in the Santa Margarita formation in the East Side field. In the West Side fields where the formations are thinner, the sand beds of the Santa Margarita become part of the productive zone. In the Kreyenhagen field the Santa Margarita shales, like the "Big Blue," form an impervious capping that keeps the oil confined in the Vaqueros sandstone.

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*Proc. Calif. Acad. Sci., 3d Series, Vol. 11, No. 2, p. 170, 1905.
†U. S. Geol. Surv. Bul. 398, p. 87.

Jacalitos formation.

The Jacalitos formation overlies the Santa Margarita shale on Reef Ridge and consists of alternating beds and zones of both soft and indurated sand, gravel, and clay, which extend up to the base of the Etchegoin formation and which form a belt along the southwest side of the Jacalitos and Kreyenhagen hills. The formation is in places 3,500 feet thick. The belt north of Coalinga consists of similar beds aggregating a much smaller thickness.

The Jacalitos formation is not petroliferous in the East Side field, but becomes very productive in the West Side field owing to the thinning out of the formations between it and the Tejon. In the Kreyenhagen field it is not known to be productive at any point, no oil appearing to have escaped from the Tejon and Vaqueros through the shales of the Santa Margarita. The thickness and character of the Jacalitos throughout the district have an important bearing on the question of the accessibility of the oil, owing to the fact that most of the wells have to penetrate it in order to reach the oil sands at depths at which they will be productive. A knowledge of its thickness has been especially useful in making calculations as to the depth at which the oil sands may be found in the region of the Kreyenhagen and Kettleman Hills fields.

Etchegoin formation.

The Etchegoin formation (Upper Miocene) consists of a succession of beds of sand, gravel, and clay which overlie unconformably the Jacalitos formation and apparently grade above into the Tulare (Pliocene) lake beds. The lower portion of the formation consists largely of beds of compact, coarse and fine bluish-gray sand alternating with zones of pebbly sand, fine gray sand and some clay. The clay increases toward the upper part of the formation, being interbedded with unconsolidated light gray sand that spreads over the surface and obscures the structure. The formation occurs in the low hills bordering the valley and passes beneath the alluvium of the valley floor.

The Etchegoin formation is nowhere within Coalinga district known to contain any petroleum, but like the Jacalitos it has an important relation to the accessibility of the oil. Some wells in the Coalinga field pass through a considerable portion or the whole of this formation before reaching the Jacalitos or lower formations. All wells drilled around the edge of Pleasant Valley, or on Anticline Ridge, or in the Kettleman Hills have to pass through at least a part of this formation, and its thickness must be taken into account in calculating the depth of the oil sands. The great increase in thickness south of Waltham Creek, in this and the other post-Eocene formations, has an all-important bearing on such calculations.

Tulare formation.

Along the border of the San Joaquin Valley the Tulare formation overlies the Etchegoin. It consists of a thick terrane of bedded but little-consolidated gravel, sand and clay with occasional indurated layers throughout and with associated beds of fresh water shells, marl and limestone at the base. The sediments of the formation, over 2,000 feet thick, were laid down under varying conditions of deposition, and marine, brackish water and fresh water beds are represented. The period of deposition probably extended from Pliocene into Pleistocene time. The formation is overlain unconformably by the more recent horizontal terrace deposits and alluvium.

The formation does not come into contact with the oil-bearing formations and contains no traces of oil. Over most of the area, in which it occurs, it is separated by so great a thickness of deposits from the productive zones that its mere presence is usually sufficient to indicate the inaccessibility of the oil.

Structure of the various formations is, generally speaking, a monocline along the flank of the Temblor range, with one large plunging anticline as an offshoot, or spur. This and other geologic features are best illustrated by the accompanying maps and cross-sections.

DIRECTORY OF OPERATING COMPANIES.

Companies Operating in Coalinga Field.

Company	Location	Wells completed	Official address	Gravity, per cent
*American Petroleum Co.	30-20-15	29	603 Security Bldg., Los Angeles	15.0
*American Petroleum Co.	18-20-15	25	603 Security Bldg., Los Angeles	17.0
*American Petroleum Co.	19-20-15	15	603 Security Bldg., Los Angeles	15.5
*American Petroleum Co.	6-20-15	26	603 Security Bldg., Los Angeles	18.0
*American Petroleum Co.	32-19-15	4	603 Security Bldg., Los Angeles	18.0
Amity Oil Co.	1-20-14	8	604 First National Bank Bldg., San Francisco	15.0
*Amy Oil Co.	6-21-15	1	Coalinga	14.5
Arica Oil Co.	7-20-15	10	Sharon Bldg., San Francisco	17.0
*Arizona Petroleum Co.	14-20-14	7	903 California Bldg., Los Angeles	13.2
Associated Oil Co.	36-20-14	37	Sharon Bldg., San Francisco	15.0
Associated Oil Co.	22-19-15	10	Sharon Bldg., San Francisco	21.4
Associated Oil Co.	8-21-15	1	Sharon Bldg., San Francisco	15.0
Associated Oil Co.	6-21-15	2	Sharon Bldg., San Francisco	--------
Azores Oil Co.	26-21-15	0		
Aztec Oil Co.	31-19-15	3	606 Wells Fargo Bldg., San Francisco	18.5
Baird Oil Co.	24-22-18	0	318 Story Bldg., Los Angeles	--------
Baltimore Oil Co.	14-18-23	0		
Berkeley-Coalinga	2-21-14	5	129 Leidesdorff st., San Francisco	17.0
Big Ten Oil Co.	10-21-15	0		
Blair Oil Co.	14-21-15	0	Coalinga	--------
Blue Diamond Oil Co.	----------	--------	Grass Valley	--------
Bohemian Oil Co.	22-21-15	1	220 N. Irvine st., Hanford	--------
*Boychester Oil Co.	18-21-15	0	Coalinga	--------
*British Consolidated Oil Co.	12-20-14	11	Coalinga	15.2
*British Consolidated Oil Co.	12-19-15	0	Coalinga	--------
*British Consolidated Oil Co.	26-19-15	2	Coalinga	20.5
*Brix & Bunting Oil Co. (see Homestead Development Co.)	----------	--------	129 Leidesdorff st., San Francisco	17.0
Caledonian Crude Oil Co.	26-20-14	3		
California Coalinga Oil Co.	8-20-15	2	915 Monadnock Bldg., San Francisco	16.0
California Counties Oil Co.	24-18	0	58 Sutter st., San Francisco	--------
California Oil and Gas Co.	6-21-15	3	Coalinga	15.6
California Oil Fields Co.	----------	--------	433 California st., San Francisco	--------
California Oilfields, Ltd.	10-19-15	10	350 California st., San Francisco, or Shell Company of California	18.3
California Oilfields, Ltd.	14-19-15	12	350 California st., San Francisco	19.9
California Oilfields, Ltd.	26-19-15	6	350 California st., San Francisco	21.0
California Oilfields, Ltd.	27-19-15	69	350 California st., San Francisco	22.8
California Oilfields, Ltd.	21-19-15	10	350 California st., San Francisco	20.0
California Oilfields, Ltd.	34-19-15	21	350 California st., San Francisco	21.0
California Oilfields, Ltd.	15-19-15	1	350 California st., San Francisco	19.0
California Oilfields, Ltd.	29-19-15	4	350 California st., San Francisco	17.0
*Call Oil Co.	32-19-15	3	Union National Bank, Fresno	18.7
Camwell Oil Co.	22-19-15	8	321 Crocker Bldg., San Francisco	20.0
Canadian Coalinga Co.	8-21-15	1	Mills Bldg., San Francisco	26.0
Caribou Oil and Mining Co.	22-19-15	24	433 Mills Bldg., San Francisco	21.7
Castle Oil Co.	4-20-15	0	1118 Hearst Bldg., San Francisco	--------
Claremont Oil Co.	24-20-14	13	Union Oil Bldg., Los Angeles	14.5
Coalinga British Oil Co.	24-20-14	21	Coalinga	15.2
Coalinga Central Oil Co. (see Homestead Development Co.)	----------	--------	--	13.0
Coalinga Crown Oil Co.	30-19-15	0	Coalinga	--------
Coalinga Eight Oil Co.	8-20-15	3	--	15.8
*Coalinga Homestake Oil Co.	26-20-14	7	Box 657, Coalinga	13.3
Coalinga Kettleman Oil Co.	4-22-17	0		
Coalinga Midland Oil Co.	10-19-15	0		
Coalinga Mohawk Oil Co.	12-20-15	3	Coalinga	27.1
*Coalinga National Oil Co.	8-20-15	1	--	14.5
Coalinga North Pole Oil Co.	6-21-15	1	Box 692, Fresno	26.0
Coalinga Metropolis Oil Co.	26-19-15	1	--	20.0
Coalinga Oil Co.	20-19-15	10	509 Wells Fargo Bldg., San Francisco	34.5

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*Member Independent Oil Producers' Agency.

Companies Operating in Coalinga Field—Continued.

Company	Location	Wells completed	Official address	Gravity, per cent
Coalinga Oil Fields Co.	32–19–15	3	433 California st., San Francisco	18.5
Coalinga Oil Fields Co.	6–21–15	2	433 California st., San Francisco	14.5
Coalinga Pacific Oil and Gas Co.	7–20–15	7	109 W. Eighth st., Hanford	16.8
Coalinga Peerless Oil Co.	22–19–15	13	824 Crocker Bldg., San Francisco	20.2
*Coalinga Petroleum Co.	14–20–14	8		13.5
*Coalinga Security Oil Co.	8–20–15	1	Coalinga	16.2
Coalinga Syndicate	31–20–15	2		15.2
*Coalinga Southpole	18–21–15	0		
*Coalinga Unity Oil Co.	12–20–14	3	Box 657, Coalinga	13.0
Coast Range Oil Co.				
C. M. Hazard	14–20–14	3	(See Queen Oil Co.)	12.5
Commercial Petroleum Co.	31–19–15	14	268 Market st., San Francisco	19.5
*Confidence Oil Co.	31–19–15	11	Box 1123, Fresno	16.6
Consolidated Oil Lands Co.	6–21–15	2	433 California st., San Francisco	22.0
Continental Petroleum Co.	2–19–15	6	(See General Petroleum Co.)	19.8
*Creme Petroleum Co.	30–30–15	2	Dinuba	14.9
Crow	2–21–14	0		
*De Luxe	6–21–15	2	(See Coalinga Oil Fields Co.)	14.5
Devil's Den Key	19–25–19	0		
Dominion Oil Co.	7–23–17	0	Coalinga	
East Coalinga, Ltd.	30–20–16	0		
El Dee Oil Co.	18–20–16	0	542 Mills Bldg., San Francisco	
Elsinore Oil Co.	8–22–15	0		
*Empire Oil Co.	32–19–15	2	(See Coalinga Oil Fields Co.)	18.5
*Esperanza Oil and Gas			(See General Petroleum Co.)	16.8
*Esperanza Land and Oil	13–21–14	0	Coalinga	
Etsenhauser Oil Co.	27–24–18	0		
Gamaphone Oil Co.	15–25–18	0		
General Petroleum Co.	6–20–15	14	Alaska Commercial Bldg., San Francisco	17.0
General Petroleum Co.	2–19–19	7	Alaska Commercial Bldg., San Francisco	19.0
Golden Oil Co.	12–22–15	0		
Good Luck Oil Co.	22–19–15	6	905 Head Bldg., San Francisco	18.0
Grove Oil Co.	2–21–14	0		
*Hawkeye Oil Co.	26–20–14	3		13.0
Homestead Development Co.	12–20–14	12	433 California st., San Francisco	15.0
Home Oil Co.	20–19–15	9	622 Merchants Exchange Bldg., San Francisco	34.0
Hub Oil Co.	22–21–15	0		
Inca Oil Co.	24–20–14	37	Sharon Bldg., San Francisco	13.7
Kern Trading and Oil	25–20–14	34	1058 Flood Bldg., San Francisco	14.7
Kern Trading and Oil	13–20–14	22	1058 Flood Bldg., San Francisco	14.5
Kern Trading and Oil	31–19–15	6	1058 Flood Bldg., San Francisco	16.0
Kern Trading and Oil	23–20–14	3	1058 Flood Bldg., San Francisco	13.0
Kern Trading and Oil	19–20–15	22	1058 Flood Bldg., San Francisco	14.8
Kern Trading and Oil	7–20–15	14	1058 Flood Bldg., San Francisco	15.7
Kern Trading and Oil	7–21–15	1	1058 Flood Bldg., San Francisco	
Kern Trading and Oil	31–20–15	16	1058 Flood Bldg., San Francisco	14.6
Kern Trading and Oil	11–20–15	0	1058 Flood Bldg., San Francisco	
Kern Trading and Oil	3–19–15	2	1058 Flood Bldg., San Francisco	24.0
Kern Trading and Oil	35–19–15	13	1058 Flood Bldg., San Francisco	24.0
Kern Trading and Oil	11–19–15	16	1058 Flood Bldg., San Francisco	19.2
Kern Trading and Oil	3–20–15	2	1058 Flood Bldg., San Francisco	19.0
Kern Trading and Oil	33–19–15	0	1058 Flood Bldg., San Francisco	
K. O. D. Oil Co.	36–20–15	0		
Lacey Oil Co.	23–25–18	0		
Lucile Oil Co.	6–21–15	4	Coalinga	14.5
Lubricating Oil Co.	12–21–14	2		
Maine State Oil Co.	31–19–15	10	280 Battery st., San Francisco	17.5
Marathon Oil Co.	13–25–18	0		
*Marion Oil Co.	6–21–15	1	Coalinga	15.0
Medallion Oil Co.	20–22–18	0	First National Bank Bldg., San Francisco	
*Mercantile Crude Oil Co.	6–20–15	5	Grant Bldg., San Francisco	14.8
Minoru Oil Co.	24–19–15	0	(See General Petroleum Co.)	

*Member Independent Oil Producers' Agency.

Companies Operating in Coalinga Field—Continued.

Company	Location	Wells completed	Official address	Gravity, per cent
*M. K. T. Oil Co.	8-20-15	1	--------	16.0
Monterey-Coalinga	14-20-14	0		
Mt. Vernon Oil Co.	31-25-19	0		
Muriel	6-21-15	--------	(See General Petroleum Co.)	--------
*Nevada Petroleum Co.	30-20-15	18	1022 Crocker Bldg., San Francisco	15.0
*Nevada Petroleum Co.	20-20-15	1	1022 Crocker Bldg., San Francisco	16.0
*Nevada Petroleum Co.	18-20-15	13	1022 Crocker Bldg., San Francisco	16.5
*New San Francisco Crude Oil Co.	6-20-15	7	Fresno	17.0
Octave Oil Co.	22-19-15	3		
Ophir Oil Co.	14-20-14	2	(See General Petroleum Co.)	--------
*Ozark Oil Co.	26-20-14	3	International Bank Bldg., Los Angeles	13.6
*Pacific States Petroleum Co.	6-21-15	1	Coalinga	26.0
Pantheon Oil Co.	32-19-15	2	First National Bank Bldg., San Francisco	19.2
Penn Coalinga Oil Co.	1-20-14	4	First National Bank Bldg., San Francisco	13.8
Penn Coalinga Oil Co.	1-20-14	7	First National Bank Bldg., San Francisco	--------
*Pilot Oil Co.	12-20-14	6	Coalinga	13.6
Pluto Oil Co.	9-23-19	0		
Portola Oil Co.	22-23-17	0		
Potter Oil Co.	35-20-14	--------	Coalinga	--------
*Premier Oil Co.	24-20-14	16	577 I. W. Hellman Bldg., Los Angeles	15.0
Progressive Oil Co.	34-20-14	0	Coalinga	--------
Record Oil Co.	22-19-15	13	--------	21.3
Recovery Oil Co.	6-21-15	2	--------	18.0
*Republic	32-19-15	1	(See Coalinga Oil Fields Co.)	18.5
Royal Dutch Shell, or Shell Co. of California	--------	--------	(See California Oilfields, Ltd., and W. K.)	--------
Sauer Dough Oil Co.	6-21-15	0	223 Crocker Bldg., San Francisco	21.3
Sauer Dough Oil Co.	22-19-15	9	223 Crocker Bldg., San Francisco	--------
Section 7 Oil Co.	7-20-15	6	--------	16.0
*Seneca Oil Co.	12-20-14	5	1411 I st., Fresno	13.0
*Shawmut Oil Co.	12-20-14	8	607 First National Bank Bldg., San Francisco	17.0
Shell Co. of California	--------	--------	343 Sansome st., San Francisco	--------
Shreves Oil Co.	6-21-15	1	Sharon Bldg., San Francisco	--------
*Silver Tip Oil Co.	6-21-15	--------	(See Consolidated Oil Lands Co.)	26.0
Southeastern, Ltd.	18-20-16	0		
*S. W. & B. Oil Co.	6-20-15	5	Box 441, Bakersfield	16.5
Southfield Oil Co.	33-22-16	0		
Southwestern Oil Co.	6-21-15	0		
*Spinks Crude Oil Co.	12-20-14	7	Monrovia	13.2
Spokane Coalinga Oil Co.	2-21-14	6	50 Third st., San Francisco	17.0
Spreckels Oil Co.	2-22-17	0		
Stockholders Oil Co.	20- 1-15	6	Phelan Bldg., San Francisco	19.6
Standard Oil Co.	28-19-15	74	Standard Oil Bldg., San Francisco	21.5
Standard Oil Co.	36-19-15	2	Standard Oil Bldg., San Francisco	22.0
*Strong Oil Co.	14-20-14	10	--------	13.0
*St. Paul Consolidated	23-20-14	17	--------	13.0
T. C. Oil Co.	18-22-18	0		
*Traders Oil Co.	26-20-14	26	Union Oil Bldg., Los Angeles	14.5
Turner Oil Co.	2-20-15	5	Shell Co. of California, San Francisco	21.5
*Twenty-two Oil Co.	22-19-15	1	Fisk Bldg., Fresno	--------
Union Oil Co.	4-20-15	0	Union Oil Bldg., Los Angeles	--------
Union Oil Co.	13-20-14	18	Union Oil Bldg., Los Angeles	14.0
*United Development Co.	17-20-15	1	--------	15.0
*United Development Co.	19-20-15	3	--------	14.5
*United Development Co.	31-19-15	0	--------	14.7
*Valley Oil Co.	32-20-15	1	Coalinga	15.8
Vancouver-Coalinga	14-20-15	0		

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*Member Independent Oil Producers' Agency.

Companies Operating in Coalinga Field—Continued.

Company	Location	Wells completed	Official address	Gravity, per cent
Walker Oil Co.	22–25–19	0		
*Ward Oil Co.	12–20–14	8	No. 3 Farmers National Bank Bldg., Fresno	13.5
Welcome Oil Co.	2–26–18	0		
White Creek Coalinga Oil and Development Co.	2–21–14	3	309 I. W. Hellman Bldg., Los Angeles	21.0
Wilcox & Fleishhacker	12–20–15	0		
Wilcox Oil Co.	12–20–15	0	Shreve Bldg., San Francisco	--------
Wilcox et al.	24–19–15	0	Shreve Bldg, San Francisco	--------
Washington Oil Co.	2–21–14	4	--------	15.0
W. K. Oil Co.	2–20–15	12	(See Shell Co. of California)	21.15
W. M. & M. Oil Co.	31–19–15	4	--------	18.5
*York Coalinga Oil Co.	6–20–15	6	--------	17.0
*Zier Oil Co.	1–20–14	18	1002 Crocker Bldg., San Francisco	13.9
Total number of completed wells	--------	1,136		

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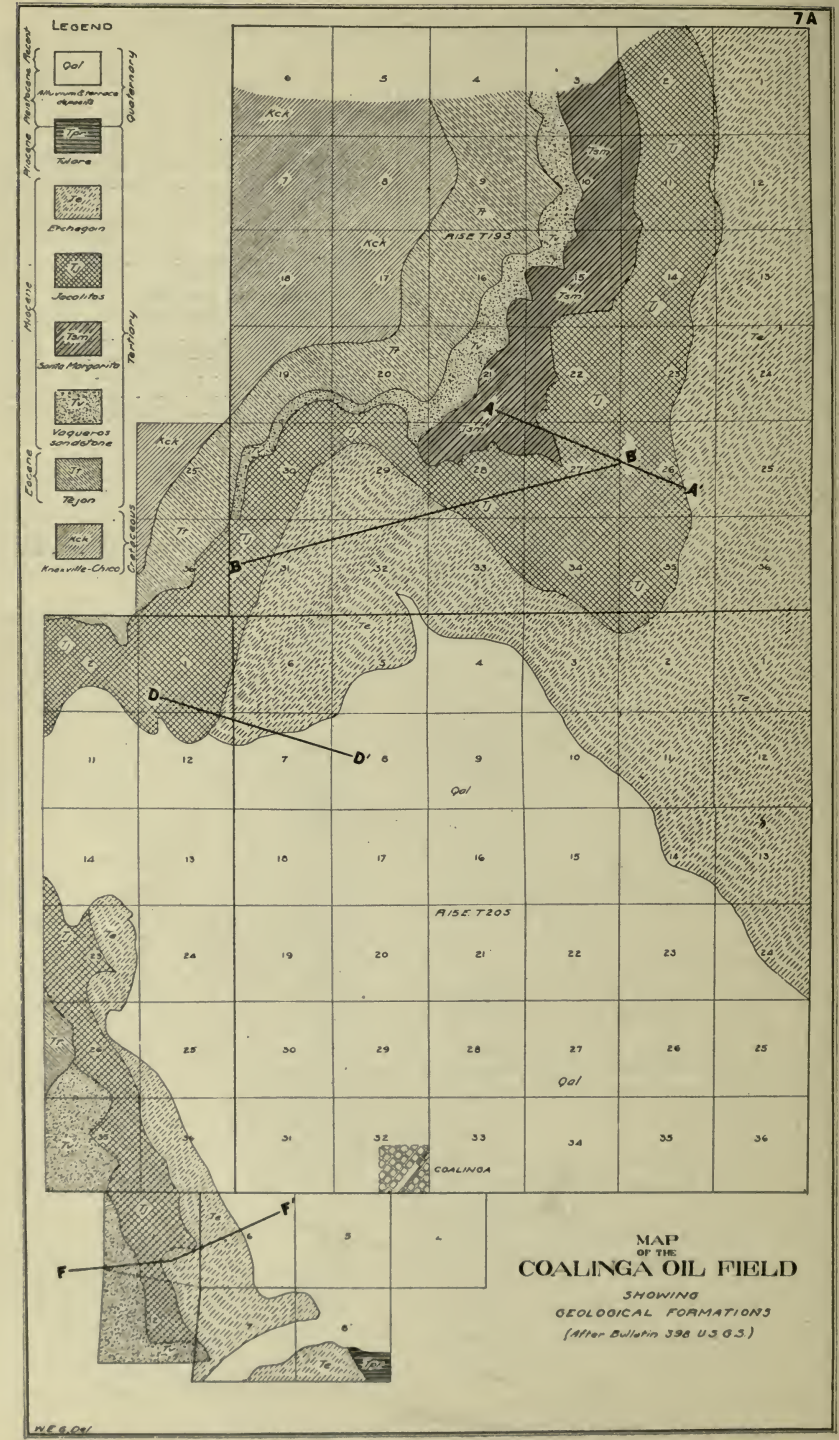
The amount of oil produced by various companies during 1913 is indicated by figures on pages 31, 35, 37, 40.



MAP OF THE COALINGA OIL FIELD

SHOWING GEOLOGICAL FORMATIONS

(After Bulletin 398 U.S.G.S.)

DRILLING METHODS AND COSTS.

The system of tabulating drilling costs of single wells, which is followed in this publication, has been recommended to the Coalinga Oil Men's Association by a committee of its members appointed for that purpose.

The cost of surface equipment is fairly constant throughout the field and appears in the following tabulations under *Derrick and Rig* and *Engines and Boilers.* Two other large items, subject to great variation, appear under the head of *Drilling* as labor and casing, which increase with the depth drilled. *Fishing and Cementing* costs are subject to considerable variation, depending upon quality of tools, skill of workmen and the nature of the ground. Costs under the head of *Finishing* are subject to some variation owing to the difference of behavior of wells upon entering the oil sand; for instance, some flow constantly while others quickly fill up with sand. *Overhead* costs, including management, superintendence, warehouse, taxes, insurance and interest, should of course be itemized, but have usually been omitted in this publication owing to the difficulty of collecting the data.

The greater part of the wells in this field have been drilled with standard (cable) tools. A considerable number have in addition used the circulator system, which pumps mud or water down through the casing, while the cable tools are running. This keeps the casing free by plastering the walls of the hole with mud and preventing caving, thereby making it possible to insert a longer string of casing than would otherwise be possible.

A number of wells have been partly drilled by rotary tools and finished with cable tools. Some of the best informed operators predict that this system will drill most of the wells in the future.

For plans of standard and rotary rigs see Plate XVI.

The following two logs are here presented as showing average typical conditions met with in the Coalinga field and also showing an excellent system of recording all the valuable information obtained in drilling a well.

Log of Well No. 20. Kern Trading and Oil Company. Description of property (*i. e.*, quarter section), SW. ¼ Sec. 19, T. 20 S., R. 15 E. Location of well, 1,150 feet north and 1,150 feet east of southwest corner of section. Elevation above sea level, 746 feet. Commenced drilling September 6, 1910. Finished drilling January 21, 1911.

Depth from—	To—	Feet	Formation
0	70	70	Yellow sand, gravel and boulders.
70	175	105	Yellow sandy clay.
175	205	30	Water sand.
205	230	25	Yellow clay.
230	284	54	Water sand.
284	295	11	Blue clay.

12½″ casing set at 286′.

295	365	70	Sand.
365	424	59	Blue clay.
424	540	116	Blue sandy clay.
540	750	210	Blue clay.
750	795	45	Blue sandy clay.
795	812	17	Blue clay.
812	850	38	Hard sand.
850	886	36	Blue clay.
886	957	71	Sand (coarse).
957	1,160	203	Blue clay.
1,160	1,170	10	Blue clay and shells.
1,170	1,208	38	Blue clay.
1,208	1,212	4	Shell.
1,212	1,232	20	Sand.
1,232	1,252	20	Blue clay.
1,252	1,257	5	Shell.
1,257	1,474	217	Blue clay.

10″ casing set at 1,369′.

1,474	1,484	10	Shell.
1,484	1,525	41	Hard sulphur sand.
1,525	1,545	20	Blue clay.
1,545	1,554	9	Shell.
1,554	1,640	86	Sand and shell.
1,640	1,697	57	Blue sandy shale.
1,697	1,701	4	Shells (sea shells). (Tamiosoma zone.)
1,701	1,802	101	Blue sandy shale.
1,802	1,803	1	Shell.

8¼″ casing cemented at 1,802′.

1,803	1,825	22	Blue sandy shale.
1,825	1,873	48	Oil sand. (Fair show of oil and gas.)
1,873	1,880	7	Shell.
1,880	1,925	45	Oil sand. (Fair show of oil and gas.)
1,925	1,965	40	Blue shale.
1,965	2,003	38	Oil sand. (Good show.)
2,003	2,012	9	Black shale.

6⅝″ casing landed at 2,009′ 5″.

Special Features.

Oil sands.

First sand, from 1,825 to 1,873 feet.
Second sand, from 1,880 to 1,925 feet.
Third sand, from 1,965 to 2,003 feet.

Important water sands.

First sand, from 175 to 205 feet.
Second sand, from 230 to 284 feet.
Third sand, from 1,484 to 1,525 feet. Sulphur water.

Casing Record.

Size of casing	Where landed	Where cut, etc.	Weight per foot	Threads per inch	Kind of shoe	Make of casing
12½″	286	------------	40	10	Plain	Reading Iron Works.
10″	1,369	------------	40	10	Plain	Reading Iron Works.
8¼″	1,802	------------	28	10	Plain	Youngstown Special.
6⅝″	2,009′ 5″	------------	20	10	Plain	Reading Iron Works.

Method of Shutting Out Water.

Size of casing	Landed at	Material	How tested and result
8¼″	1,802	Shell	Cemented with 5 tons of Golden Gate cement pumped in with tubing. The cement was mixed and pumped in in 45 minutes. Hole was bailed dry and stood so for 12 hours. Then drilled through cement and into sand at 1,825′. Bailed hole dry and it remained so 48 hours.

Remarks: Cement set 26 days.
Heaving plug: Material, fir wood; length 5 feet; where set, 2,007 feet top of plug.
Adapters: Material, none.

Perforated by A. Ferguson machine.

From—	To—	Number of feet	Rows	Centers	Holes	Remarks
1,965	2,003	38	3	3½″	½″ x ¾″	
1,825	1,925	100	3	3½″	½″ x ¾″	

Rating of Well After Thirty Days.

Barrels of oil per day (24 hours).
Per cent of water, gravity.
Drillers: Loftis, Limburger, Christie, Farr. Toolies: Laird, Kelley.

Log of Well No. 40—Section 35-A. Kern Trading and Oil Company. Description of property (*i. e.*, quarter section): NW. ¼ section 35-19-15. Location of well, 625 feet east and 150 feet south of northwest corner. Elevation above sea level, 942.03 feet. Commenced drilling September 17, 1912. Finished drilling April 9, 1913.

Depth from—	To—	Feet	Formation
0	20	20	Sandstone.
20	140	120	Blue clay and gravel.
140	160	20	Blue shale.
160	170	10	Gray sandstone.
170	180	10	Blue sandy shale.
180	200	20	Blue shale.
200	210	10	Dry sand.
210	290	80	Blue shale.
290	305	15	Water sand.
305	325	20	Blue shale.
325	330	5	Water sand.
330	345	15	Blue shale.
345	415	70	Sandy shale.
415	450	35	Blue shale.
450	460	10	Gravel.
460	475	15	Water sand.
475	485	10	Blue shale.
485	525	40	Water sand.
525	590	65	Blue shale.
590	620	30	Water sand.
620	650	30	Shale.
650	665	15	Gray mud.
665	745	80	Sticky blue shale.
745	750	5	Hard shell.
750	790	40	Sandy shale.
790	1,025	235	Blue shale.
1,025	1,040	15	Sandy shale.
1,040	1,055	15	Hard dry mud.
1,055	1,080	25	Blue shale.
1,080	1,100	20	Water sand.
1,100	1,165	65	Blue shale.
1,165	1,172	7	Dry sand.
1,172	1,220	48	Sandy blue shale.
1,220	1,255	35	Blue shale.

15½" casing landed at 1,244'. NAT. D. B. X. C. & G. 70 pounds.

1,255	1,280	25	Sandy shale.
1,280	1,290	10	Shell.
1,290	1,340	50	Blue shale and shell.
1,340	1,405	65	Muddy sand.
1,405	1,410	5	Sea shells.
1,410	1,440	30	Water sand.
1,440	1,564	124	Sand and shell.
1,564	1,567	3	Hard shell.
1,567	1,579	12	Sand—dry.
1,579	1,602	23	Blue sandy shale.
1,602	1,636	34	Black sandy shale.
1,636	1,690	54	Blue shale.
1,690	1,702	12	Green shale.
1,702	1,708	6	Gray sand.
1,708	1,723	15	Green shale.
1,723	1,728	5	Red rock.
1,728	1,751	23	Green shale.
1,751	1,754	3	Red rock.
1,754	1,761	7	Green shale.
1,761	1,775	14	Red rock.
1,775	1,781	6	Sandy blue shale.
1,781	1,790	9	Red rock.
1,790	1,810	20	Green shale.
1,810	1,820	10	Red rock.
1,820	1,834	14	Green shale and fine gravel.
1,834	1,847	13	Red, white and green shale.
1,847	1,880	33	Dry sand and shell.
1,880	1,888	8	Sandy blue shale.
1,888	1,917	29	Oil sand.
1,917	1,927	10	Conglomerate.

12½" casing set at 1,925'. NAT. D. B. X. 45 pounds.

Depth from—	To—	Feet	Formation
1,927	1,929	2	Limestone.
1,929	1,953	24	Oil sand.
1,953	1,970	17	Sandy shale.
1,970	1,976	6	Dry sand.
1,976	2,013	37	Sandy shale.
2,013	2,020	7	Hard shell.
2,020	2,028	8	Gray sand.
2,028	2,030	2	Shell.
2,030	2,065	35	Sandy blue shale.
2,065	2,070	5	Brown shale.
2,070	2,076	6	Blue shale.
2,076	2,089	13	Sand.
2,089	2,101	12	Brown shale.
2,101	2,116	15	Black sand—show of oil.
2,116	2,154	38	Sandy shale.
2,154	2,163	9	Black shale.

10″ casing cemented at 2,158′. NAT. D. B. X. 40 and 48 pounds.

2,163	2,165	2	Shell.
2,165	2,167	2	Oil sand.
2,167	2,200	33	Sandy shale.
2,200	2,204	4	Blue shale.
2,204	2,208	4	Oil sand.
2,208	2,243	35	Sandy shale.
2,243	2,254	11	Sandy shale with streaks of oil sand.
2,254	2,293	39	Hard oil sand.
2,293	2,297	4	Sandy blue shale.
2,297	2,309	12	Muddy sand.
2,309	2,311	2	Shell.
2,311	2,330	19	Blue shale.
2,330	2,335	5	Shell.
2,335	2,346	11	Oil sand and shell.
2,346	2,360	14	Blue shale.
2,360	2,363	3	Hard shell.
2,363	2,377	14	Blue shale.
2,377	2,387	10	Hard shell.
2,387	2,448	61	Blue shale.
2,448	2,495	45	Hard oil sand—good show.
2,495	2,505	10	Sandy shale.
2,505	2,520	15	Oil sand.
2,520	2,521	1	Hard shell.
2,521	2,530	9	Oil sand.
2,530	2,532	2	Shell.
2,532	2,550	18	Brown shale.

8¼″ casing set at 2,550′. NAT. D. B. X. 36 pounds.

Special Features.

Oil sands.

First sand, from 2,204 to 2,208	4 feet
Second sand, from 2,254 to 2,293	39 feet
Third sand, from 2,335 to 2,346	11 feet
Fourth sand, from 2,448 to 2,495	43 feet
Fifth sand, from 2,505 to 2,520	15 feet
Sixth sand, from 2,521 to 2,530	9 feet

Important water sands.

First sand, from —— to —— — feet

Casing Record.

Size of casing	Where landed	Where cut, etc.	Weight per foot	Threads per inch	Kind of shoe	Make of casing
15½"	1,244	Not	70	10	Baker	Nat. D. B. X.
12½"	1,925	Not	45	10	Baker	Nat. D. B. X.
10"	2,158	Not	40 & 48	10	Plain	Nat. D. B. X.
8¼"	2,550	Not	36	10	Plain	Nat. D. B. X.

607 feet of 48 pound casing on bottom of 10 inch string.

Method of Shutting Out Water.

Size of casing	Landed at	Material	Kind of cement	How tested and result
10"	2,158'	Black shale	Mt. Diablo	Put in with dump boiler. Set 9 days. Bailed dry. Stood so 15 hours. Job O. K.

Remarks: Larkin packer set at 2,100 feet. One joint of tubing below packer.
Heaving plug: Material, —.
Adapters: Material, —.

Perforated by——Shop Perforated.

From—	To—	Number of feet	Rows	Centers	Holes	Remarks
2,155	2,550	395	7	5"	½"	

Rating of Well After Thirty Days.

Barrels of oil per day (24 hours).
Per cent of water, gravity.
Drillers: Brown, Stahler, Harpater, Letton. Toolies: Bump, Davis, Gormley.

Log of Well No. 40—Section 35-A, Kern Trading and Oil Company.

The well was spudded in September 18, 1912. The 15½ inch casing was landed at 1,244 feet and the 12½ inch at 1,925 feet. At 2,158 feet the 10 inch casing was cemented with 74 sacks of Mount Diablo put in with dump bailer. The cement set for 9 days and the casing tested dry. Drilled ahead and the job was O. K. The 8¼ inch casing was carried to 2,550 feet and set. On the bottom of this string is 395 feet of shop perforated casing extending from 2,155 feet to 2,550 feet with 7 rows ½ inch holes and 5 inch centers. There was 2,000 feet of oil in the hole and no water, so an 8¼ inch Larkin packer was put on with one joint of tubing below it. The well was now put on the pump and made 255 barrels the first 15 hours, pumping by heads—8 minutes between flows. The well continued to pump at about 350 barrels per day until the eleventh day, when it began to flow steadily between 1,100 and 1,200 barrels per day.

There was no junk left in the hole.

It will be noted from these logs that from 25 per cent to 30 per cent of the formation encountered is sand in beds varying in thickness from 2 feet to 124 feet and averaging 25 feet to 48 feet thick in the two wells. The sand is seldom hard enough to be called stone; on the surface it is usually soft enough to readily break with a hand pick.

The remainder of the logs show clay, shale or sandy shale which are also comparatively soft.

Cost of labor and equipment is indicated by the following:

Drilling Cost of Four Wells—East Side Field—Various Depths—Standard Tools.

Derrick and rig	1,330 ft.	2,083 ft.	2,485 ft.	2,830 ft.
Labor making grade	$20 00	$15 65	$8 90	$20 00
Lumber, nails, bolts, etc.	1,126 00	1,303 21	1,421 34	1,593 64
Rig irons	495 42	495 42	495 42	690 00
Teaming	137 75	72 20	66 38	150 00
Planing mill material and labor (oak arms, cants, etc.)	85 50	84 55	111 60	126 25
Machine shop work on bolts and rods	1 80	2 75	7 60	12 50
Labor building rig, including placing rig irons	265 00	265 00	295 00	250 00
Total derrick and rig	$2,131 47	$2,238 78	$2,406 24	$2,842 39
Rigging up.				
General supplies, including lumber, line pipe, engine and boiler fittings, brick, lime and sundry fittings	$678 71	$537 90	$533 43	$743 34
Teaming	87 90	61 00	87 67	100 00
Shop work	12 75	11 75	22 40	66 00
Labor	566 20	605 63	587 66	594 30
	$1,345 56	$1,216 28	$1,231 16	$1,503 64
Engines and boilers.				
Maintenance covered by general drilling expenses charged below.				
Removed on completion of well and replaced by gas engine as below.				
Drilling.				
Belts	$87 73	$175 46	$228 27	$159 29
Bull ropes	44 20	65 50	69 30	63 68
Casing	5,316 73	8,562 50	10,481 10	13,567 84
General supplies	660 25	1,439 61	1,205 23	1,443 93
Machine shop work	142 45	363 95	318 60	447 55
Teaming	189 47	320 98	268 12	569 85
Labor (including installing tubing and pumps)	2,081 30	4,244 77	3,987 45	4,748 80
General drilling expense, including drilling lines, upkeep of tools, proportion of drilling superintendent's salary, etc.	1,820 00	3,600 00	3,000 00	3,640 00
	$10,342 13	$18,772 77	$19,558 07	$24,640 94
Fuel.				
Natural gas used, no cost	----------	----------	----------	----------
Water	$120 00	$120 00	$180 00	$180 00
Gas engine.				
One 25 horsepower	$665 00	$665 00	$665 00	$665 00
Labor installing and fitting	66 71	66 71	88 30	88 30
	$731 71	$731 71	$753 30	$753 30
Labor.				
Removing steam engine and boilers	$20 00	$20 00	$20 00	$20 00
Tubing	400 30	400 30	799 20	799 20
Rods	122 40	122 40	243 00	243 00
Pump	20 22	20 22	24 51	24 51
Tankage	327 50	327 50	327 50	327 50
Totals	$15,561 29	$23,969 96	$25,542 98	$31,334 48
Total cost per foot	$11 70	$11 49	$10 28	$11 08
Casing cost per foot	4 00	4 11	4 21	4 80
Labor cost per foot	2 02	2 34	1 85	1 90
Drilling labor cost per foot	1 56	2 04	1 60	1 68
Actual working time (spudding to pumping), days	80	160	149	175
Feet per day	16.6	13.0	16.7	16.2

Wages.	
Drilling crew (12 hours), one driller	$7 00
Drilling crew (12 hours), one tool dresser	4 50
Tubing gangs (12 hours), foreman	4 00
Tubing gangs (12 hours), laborers	3 25

Standard tools on another property drilled 14 wells averaging 1,785 feet in depth at cost per foot of $1.65 for labor and $8.18 for material.

Itemized Cost of Materials on Three Wells. (Standard Tools)

Not Including Bits, Stems, etc.

Depth	1,738 ft.	1,850 ft.	1,976 ft.
Casing stove pipe	441 ft.	490 ft.	
Casing stove pipe, 12-inch	1,055 ft.	1,227 ft.	
Casing stove pipe, 10-inch	1,548 ft.	1,661 ft.	
Casing stove pipe, 8-inch	1,733 ft.	1,850 ft.	
Ball bearings temper screws	$2 30	$2 65	$3 30
Belt clamps	------------	70	------------
Babbitt	5 07	13 41	9 45
Brick	53 30	55 98	55 25
Boiler	485 00	485 00	475 00
Belts	95 02	95 40	94 50
Blacksmith coal	1 56	1 92	------------
Bull rope	45 45	50 09	97 94
Casing wagon wheels	------------	5 00	------------
Casing (screw)	9,065 46	8,731 01	9,645 34
Casing (stove pipe)	------------	1,482 65	1,316 75
Casing head	------------	------------	7 00
Cement	99 90	99 90	99 90
Casing shoes	161 00	197 15	190 45
Casing head clamp	10 75	------------	------------
Crank pin brass	------------	8 55	------------
Cup grease	1 17	2 72	2 10
Cup grease cups	84	------------	------------
Casing clamps	41 65	20 05	20 05
Corrugated iron	14 80	14 88	------------
Casing collar	25 66	39 63	73 20
Distillate	1 60	1 20	4 46
Engine	310 00	310 00	310 00
Flue cleaner	3 70	------------	------------
Fittings	132 57	244 84	284 90
Guy wire	18 64	39 20	15 63
Heaving plug	------------	8 00	8 25
Hardwood	92 85	90 30	119 55
Hose	------------	42 00	51 00
Jars	------------	82 25	------------
Jack post box	------------	33 00	------------
Lagging rope	------------	20 00	20 00
Lumber	963 75	899 51	961 53
Lubricator	23 75	10 00	12 50
Machine bolts	10 87	43 54	33 51
Manila cables	284 25	210 56	321 95
Manila rope	4 63	9 68	7 62
Nails	50 83	31 00	4 54
Oil	27 87	46 62	61 20
Oil cans	5 61	8 28	8 25
Packing	23 14	15 61	44 32
Paint	1 40	1 40	------------
Packing clamps	18 00	20 00	18 00
Perforating	27 00	191 00	54 29
Polish rod substitute	90	90	------------
Polish rod	1 75	1 75	------------
Pump, complete	32 95	20 00	44 00
Pulleys	1 50	3 18	1 98
Pipe, ½-inch	7 64	5 75	4 24
Pipe, 1-inch	22 45	28 05	24 66
Pipe, 2-inch	296 99	449 32	297 64
Pipe, 3-inch	135 10	------------	------------
Repair tools	277 13	35 49	131 72
Repair casing	------------	5 40	10 00
Rig irons	550 76	712 49	730 13
Rig building	235 00	------------	------------
Rubber (packer)	35 08	25 50	34 40
Safety valve	7 20	------------	------------
Sand reel lever	------------	3 75	------------
Stuff box	4 45	4 45	------------
Sand lines	129 92	142 07	142 80

Itemized Cost of Material on Three Wells (Standard Tools)—Continued.

Sucker rods	$154 50	$170 00	$195 70
Tanks	174 00	174 00	----------
Tallow	6 25	6 50	3 50
Tubing, 2-inch	1 44	----------	----------
Tubing, 3-inch	484 84	537 71	613 70
Turnbuckles	----------	22 20	----------
Throttle cord and wheel	1 10	1 50	1 85
Tools	----------	8 90	521 96
Waste	33	54	2 64
Wire line clamps	65	45	----------
Washers	23 37	10 36	3 00
White lead	1 65	3 47	1 05
Wire cables	610 80	557 70	706 40
Totals	$15,307 14	$16,596 11	$17,903 10
Total per foot	8 80	8 96	9 06
Casing, per foot	5 21	5 52	5 54

The rate of drilling largely governs the cost of labor. As shown by records from 169 wells taken at random over the field it varies from 9 to 16 feet per day with an average of about 12 feet. Figures usually include rigging up and extend until production begins. That such performances are, however, below what should be expected with improved tools and systematic methods is shown by the fact that one company in the field drilled nine wells averaging 2,000 feet in depth with standard tools at the rate of 19 feet per day. Rotary tools were used in drilling 14 more wells, averaging 2,005 feet deep, at the rate of 37 feet per day and the rivalry increased the rate at five other wells, drilled with standard tools to 25 feet per day. The method of computing drilling time probably does not conform to that stated above and therefore the comparison is not direct, but may be of some value.

A neighborhood property using standard tools drilled 14 wells averaging 1,820 feet in depth, finished with 8¼ inch casing at the rate of 15.9 feet per day; 5 wells averaging 1,930 feet in depth, 6⅝ inch casing, 13.1 feet per day, and one well 2,350 feet deep, 4½ inch casing at the rate of 9.7 feet per day.

Two necessities for fast drilling are skillful, industrious workmen and a system which provides that they shall lose no time waiting for material or tools.

Comparisons of the various methods of drilling must of course rest upon the final cost of wells finished in equally good condition. It is difficult to present such a comparison, due to different methods, or lack of method, in keeping costs. However, such figures as were obtainable are here presented and afford a basis for comparison.

Amount of Casing, 133 Wells—Coalinga Field.

Group	Number of wells	Depth			Stove pipe			12½-inch			10-inch			8¼-inch			6⅝-inch			4-inch		
		Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.
A	10	1,277	1,143	1,423	-------	-------	-------	-------	-------	-------	1,065	863	1,214	1,215	939	1,355	1,275	4 wells 1,143	1,369	None		
B	20	1,319	970	1,950	-------	-------	-------	505	3 wells 70	980	915	14 wells 662	1,086	1,151	700	1,410	1,375	11 wells 913	1,661	1 well		
C	26	1,810	1,500	2,115	460	285	541	1,125	859	1,417	1,600	1,280	1,836	1,760	1,500	2,050	1,870	4 wells 1,738	2,110	None		
D	16	1,842	1,495	2,254	150	2 wells 15	370	907	2 wells 587	1,347	1,478	1,092	2,090	1,740	1,234	2,244	1,810	8 wells -------	-------	None		
E*	12	1,920	1,770	2,371	227	-------	-------	814	-------	-------	1,348	6 wells 702	1,895	1,670	1,436	2,212	1,940	1,762	2,371	None		
F	11	2,032	1,839	2,467	384	7 wells 21	494	1,187	982	1,509	1,790	1,581	2,320	1,966	1,565	2,467	To bottom 4 wells			To bottom 1 well		
G*	10	2,337	2,240	2,460	118	68	190	1,009	4 wells 635	1,257	2,025	1,655	2,275	2,233	2,112	2,402	2,320	7 wells 2,253	2,444	To bottom 1 well		
H*	16	2,808	2,447	3,133	210	40	605	1,460	787	1,761	2,300	2,011	2,581	2,642	2,480	2,967	2,790	2,547	3,133	To bottom 2 wells		
I	9	3,029	2,775	3,378	-------	-------	-------	1,600	1,016	1,935	2,330	1,717	2,658	2,692	2,240	2,885	2,850	2,610	3,038	3 wells 3,054	2,770	3,378
J	3	4,240	3,978	4,660	1,021	16 inch 837	1,205	980	1,773	2,187	2,860	2,455	3,153	3,790	3,252	4,183	4,100	3,758	4,473	To bottom 1 well		

*E—Rotary 6 wells to average 1,510 feet finished with Standard.
*G—Rotary 8 wells to average 1,730 feet finished with Standard.
*H—Rotary 12 wells to average 2,210 feet finished with Standard.

Amount and Cost of Casing for Various Depths.

	800 to 1,500 feet		1,500 to 2,000 feet		2,000 to 3,000 feet		3,000 feet +		Price of casing per ft.
Number of wells	30 (av. 1,305)		54 (av. 1,844)		37 (av. 2,450)		12 (av. 3,332)		
Feet drilled	39,150		99,572		90,650		39,881		
Feet per day									
Stove pipe casing	----------	----------	14,812 ft.	$35,697	8,410 ft.	$20,268	3,063 ft.	$7,382	$2 41
12″	1,515 ft.	$2,651	45,390 ft.	79,433	40,453 ft.	70,793	20,340 ft.	35,595	1 75
10″	23,460 ft.	40,586	73,336 ft.	126,871	76,740 ft.	132,760	29,550 ft.	51,122	1 73
8″	35,170 ft.	40,446	93,640 ft.	107,686	86,228 ft.	99,162	35,598 ft.	40,938	1 15
6″	20,225 ft.	21,236	45,240 ft.	47,502	69,008 ft.	72,458	37,950 ft.	39,848	1 05
4″	1,320 ft.	818	----------	----------	9,985 ft.	7,389	13,402 ft.	8,309	62
Casing total	----------	$105,737	----------	$397,189	----------	$402,830	----------	$183,194	----------
Casing per foot of hole	----------	$2 70	----------	$3 99	----------	$4 44	----------	$4 58	----------

These performances can doubtless be improved upon in the future, as the many neighboring wells afford data for exact points where casing should be landed.

A comparison of the cost with standard and with rotary tools is not possible as the rotary has not been so extensively used as in other fields.

Rotary tools have not thus far been generally adopted in the Coalinga field and many operators do not consider them to be superior to standard tools. However, some operators maintain that tests have not been final and that the use of rotary tools has been very beneficial in causing standard workmen to do better and faster work lest they should be displaced.

The rate of depreciation of rotary tools is indicated by the fact that one company used up four machines in drilling sixteen wells about 2,000 feet deep. Most of the wear is on the drill pipe and not the tables.

Perforating of casing where it is in oil sands is done by two methods, shop and machine. Machines punch slots after the casing is landed, and shop perforating consists of drilling holes in the casing before placing it in the well. Machines are frequently of advantage where casing can not be withdrawn from the well. Among the disadvantages of machine perforating are undue or misplaced mutilation of the casing, causing it to collapse by sand pressure, or break in two if it should be pulled for repairs to the wells.

Some customary dimensions are:

	Size of holes	Rows	Distance between centers
Machine	5/8″ x 1½″	4	8″
	½″ x ¾″	3	3½″
Shop	½″	4 or 5	6″
	3/8″	4 or 5	6″
	3/8″ x 1″	4 or 5	6″

Comparison of costs by standard tools with and without the circulating system afforded by the following figures from five different groups of wells.

Drilling Cost per Foot With and Without Circulator System—Coalinga.

Number of wells	Average depth	Average cost per foot	
		Standard	Circulating
4	1,914	$8.247	
4	2,142		$9.616
4	1,853	9.019	
7	2,190		8.695
10	1,663	9.177	
8	2,168		7.699
4	1,892	10.849	
2	1,835		9.299
7	1,939	9.853	
9	2,473		8.412

FUEL OIL USED IN DRILLING.

Standard tools	10 barrels per day
Standard tools, with circulator	14 barrels per day

Wages of drilling crews:

Standard.

1 driller	$7 00 per tour
1 tool dresser	4 50 per tour*
Total crew	$23 00 per day*

Standard—Circulating.

1 driller	$7 00 per tour
1 tool dresser	4 50 per tour
1 circulator man	3 50 per tour
Total crew	$30 00 per day

Rotary.

1 driller	$7 00 per tour
4 helpers at	4 00 per tour
Total crew	$46 00 per day

CABLE USED IN DRILLING.

Cable used with standard tools is usually steel, one inch in diameter. The amount of wear is indicated by the fact that on one large property 26 lines each 3,000 feet long drilled 54,552 feet of hole. (1 foot cable = .7 foot hole, or 1 foot of hole = 1.43 feet of cable.)

POWER REQUIRED IN DRILLING.

Power required to drill with standard tools is indicated by the following test figures taken at a well 876 feet deep with a 9″x12″ steam engine:

Operation	Revolutions per minute	Indicated horsepower
Lifting tools	230	19.83
Lifting tools	88	7.58
Bailing	118	9.93
Lifting sand pump	128	22.41
Drilling	116	7.88
Drilling	162	10.41
Drilling	168	14.29
Drilling	164	9.61
Drilling	182	13.76

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*1 tour = 12 hours; day = 24 hours.

CEMENTING.

Cementing has been described in a general way in other publications (*e. g.* Technical Paper 32, U. S. Bureau of Mines), but figures on actual operations may be of value.

A convenient size of mixing box is 10′ x 20′ x 1′, allowing several men on each side to mix with hoes as the cement and water are added. Ordinarily from 7 to 10 gallons of water per 100 pounds of cement are used, making a readily flowing mixture about the consistency of cream.

Two pumps of the "Gumbo Buster" type should be connected in case an accident should disable either one. Pressure of 600 or 700 pounds per square inch is frequently necessary to start circulation, which is only continued until a free passage is assured and not until all mud is removed which might cause the hole to cave and "freeze" the casing.

Various cements on the market have been shown to be of about equal value, providing initial set occurs within 3 or 4 hours. Amount used, according to Mr. R. D. Bush, is about as follows:

Depth, 1,000 feet to 2,000 feet.	
10-inch casing with 500 feet to 700 feet friction	5 to 7 tons
10-inch casing with 100 feet friction	1½ to 2 tons
Depth, 2,000 feet to 3,500 feet.	
8¼-inch casing with 500 feet to 700 feet friction	3 to 5 tons
8¼-inch casing with 100 feet friction	1 to 2 tons

In two known instances 10-inch casing was ripped out and five tons of cement was found to have filled the space for about 180 feet from bottom. Both wells were drilled by cable tools with little or no reaming.

An estimate of cost, aside from regular drilling crew, is as follows:

Inserting and pulling tubing, 2 extra men, 5 hours	$3 50
Hauling cement	5 00
Hauling box and pump	2 00
Pump man and helper (set up)	3 75
Mixing (2 men, 6 hours)	5 00
Cement (10 tons)	200 00
Total	$219 25

TOTAL COST OF PRODUCING OIL.

(Various Depths and Value of Land.)

The following figures are based upon the two factors (unit cost of drilling and pumping and life of wells) which are more fully dealt with elsewhere in this chapter. Ideal conditions (without water trouble, accidents to wells, etc.) are assumed over an area of 160 acres. Ten wells to be drilled during the first year and ten more later. Fixed charges to return capital with 10 per cent interest during ten years (not including first year). Such a rate of interest is very low, when possibility of accidents and unforeseen trouble are considered and the final figures may be deemed *actual cost without profit.* While the figures of production are entirely hypothetical it will be noted that they conform closely to those represented by diagrams of actual conditions.

Wells costing $20,000 each.

	Cost of oil per barrel.
Land at $2,000 per acre	52 cents
Land at 1,000 per acre	43 cents
Land at 500 per acre	38 cents
Land at 100 per acre	34 cents
Land free	33 cents

Wells costing $10,000 each.

	Cost of oil per barrel.
Land at $1,000 per acre	34 cents
Land at 500 per acre	28 cents
Land at 100 per acre	26 cents

The method of deriving the above figures is as follows:

Assume wells at $20,000 each, land at $1,000 per acre.

Capital invested—

Land	$160,000 00
Ten wells	200,000 00
Equipment	40,000 00
Total	$400,000 00

Ten annual payments of $74,000 each would be required to replace capital with 10 per cent interest, the annual payments being re-invested at 4 per cent compound interest. Equipment (including buildings, tanks, pipes, etc.) is here figured too low; extensive operations show it to be about 33 per cent of total cost of wells.

Production				
Total per year	Per well day			
		First year:		
		Pumping (at $6.00 per well day) 10 wells, six months	$11,000	
		Overhead (superintendent, manager, etc.)	12,000	
135,000	------			$23,000
		Second year:		
		Drilling one well	$20,000	
		Pumping 10 wells	22,000	
		Overhead	12,000	
		Fixed charges	74,000	
450,000	123			128,000
		Third year:		
		Drilling 2 wells	$40,000	
		Pumping 11 wells	24,000	
		Overhead	12,000	
		Fixed charges	74,000	
450,000	112			150,000
		Fourth year:		
		Drilling 2 wells	$40,000	
		Pumping 13 wells	28,500	
		Overhead	12,000	
		Fixed charges	74,000	
450,000	95			154,500
		Fifth year:		
		Drilling 3 wells	$60,000	
		Pumping 15 wells	33,000	
		Overhead	12,000	
		Fixed charges	74,000	
450,000	83			179,000
		Sixth year:		
		Drilling 2 wells	$40,000	
		Pumping 18 wells	39,500	
		Overhead	12,000	
		Fixed charges	74,000	
330,000	68			165,500
		Seventh year:		
		Pumping 20 wells	$44,000	
		Overhead	12,000	
		Fixed charges	74,000	
288,000	40			130,000
		Eighth year (same as seventh):		
248,000	34			130,000
		Ninth year (same as seventh):		
219,000	30			130,000
		Tenth year (same as seventh):		
190,000	26			130,000
		Eleventh year (same as seventh):		
160,000	22			130,000
3,370,000	------	Total (21,000 bbls. per acre)	----------	$1,450,000
		Or	43 cents	per barrel.

Doubtless the property would produce for several years more at a profit above bare operating cost. The length of life of the property would depend upon the initial number of wells. Theoretically one well would drain the entire property if given a long enough time. If twenty years were chosen in which to repay capital with 10 per cent interest, the anual fixed charge (for the above ten years) would have been $58,000 instead of $74,000 and the price per barrel 38 cents.

If the capital were merely returned without interest, which of course is absurd, it would require an annual deposit, or fixed charge, of $33,316 at 4 per cent compound interest and the total cost would be 31 cents per barrel.

For a more complete description of a similar method of computation, the reader is referred to work of H. C. Hoover, "Principles of Mining," New York, 1909, pp. 42 to 50.

HAULING COSTS.

Hauling being a considerable item of expense in the various branches of operation, the following figures may be useful.

The roads in and about the oilfields are far from good, as the soil affords no sound basis for road building. Repairs usually consist of smoothing off the worn surface and sprinkling with low gravity oil. Heavy teaming soon squeezes such a road into hummocks.

Roads not sprinkled with oil soon grind into fine dust several inches in depth. Traction engines with trail wagons, automobile trucks and teams are all in common use.

Traction engines. One large concern has used traction engines for five years in hauling a distance of nearly nine miles from the railroad. A load of thirty tons is drawn on four trail wagons, making the distance in about five hours. Cost per ton mile is reported as having been 21 cents, which includes 10 per cent depreciation.

Another operator gives the following incomplete figures, covering a period of 29 days (without depreciation or complete repairs):

Total tonnage hauled, 625.6.
Average distance (estimated), 7.2 miles.
Total ton miles, 4,495.0.
Average tons per day, 21.6.

Engineer at $5.00	$145 00
Fireman at $4.00	116 00
Fuel (5 barrels per day at 60¢)	87 00
Cylinder oil (10 gallons at 31¢)	3 10
Red engine oil (10 gallons at 21¢)	2 10
Sundry fittings	3 80
Upkeep (rolling flues)	11 58
Total	$368 58
Per day	7 93
Per ton mile	.082

Automobile trucks. The operator using a traction engine for 9 miles also reports using a 3-ton truck at a cost of 23 cents per ton mile, including repairs and 20 per cent depreciation.

Some of the expenses for an automobile truck are as follows for thirty-one days. It will be noted that these figures are incomplete as they include no repairs or depreciation:

Total tonnage hauled, 277.7.
Average distance, 8.4 miles.
Total ton-miles, 2,335.2.

Labor (driver at $4.00)	$116 00
Gasoline (251.5 gallons at 20¢)	50 30
Lubricating oil (13.4 gallons at 43¢)	5 88
Total	$172 18
Per day	5 55
Per ton mile	.073

Teams. For ordinary hauling 4 horses (or mules) with a wagon and trailer are usual. Feeding hay at the rate of 21.5 pounds per day and grain (mixture of 4 barley to 1 corn) 6.7 pounds per day (the rate shown by one account of 60 animals for 6 months) amounts to about 25 cents per day, per animal.

A driver usually is paid $3.50 per day. Weight of load varies from seven to ten tons.

As distance and accommodations are so variable no exact figures were obtained. Probably 21 cents to 25 cents per ton mile is a fair estimate, excluding depreciation.

PUMPING METHODS AND COSTS.

Pumping in the Coalinga field is done with steam, gas and electric power. Most of the wells have individual engines or motors. Some of the larger properties have central steam power plants. Almost no wells are pumped by jacks.

According to Mr. R. E. Collom, the three sources of power were used about as follows during 1913:

	West side, number of wells	East side, number of wells	Per cent of oil produced
Steam	327	38	61.5
Gas	180	286	31.0
Electricity	49	19	3.0
Flowing	----------	----------	4.5

Costs of pumping will here be shown as far as possible, for the following three subdivisions: Power plant, pumps, and wells. Each in turn being divided into initial expense, operation and repairs.

Steam equipment cost is partly accounted for under the head of drilling expense as the same engine is used and frequently the same boilers.

POWER REQUIRED TO PUMP OIL WELLS.

Amount of power required in the various operations of pumping wells is indicated by the following tests, with a steam engine, on wells producing oil at about 15° Baumé.

Depth of well	Pumping depth	Revolutions per minute	Indicated horsepower
1,065	860	96.4	6.1
1,075	920	71.6	4.7
1,053	840	55.0	2.8
929	840	84.8	2.6
1,023	960	56.3	3.0
1,050	980	10.3	4.4

Average indicated horsepower	3.91
Average pumping depth (feet)	932.9
Average pumping speed (revolutions per minute)	78.6

Pulling Rods—Length 940′, Size of Engine, 9″ x 12″.

Average revolutions per minute	212.8
Total time (minutes)	25
Average indicated horsepower	14.08

Another series of careful tests on five wells showed an average consumption of 6.98 horsepower per well in pumping. The engine and band wheel absorbed 22 per cent of that power.

Pulling Tubing.

Average revolutions per minute	219.9
Number stands	18
Total time (hours)	1
Size (inches)	3
Length (feet)	940
Average indicated horsepower	14.85

Lifting Sand Pump.

Number of lifts	3
Size of pump	6″ x 16′
Lift feet	1040
Size cable (inches)	$\frac{7}{8}$
Average revolutions per minute	182.46
Average time per lift (minutes)	$6\frac{1}{3}$
Average indicated horsepower	25.4

TREATMENT OF BOILER WATER.

Water obtained from wells in the Coalinga field contains considerable mineral. This causes scale in boilers and consequent high cost due to cleaning and repairing, besides excessive amounts of fuel used.

The best practice is to treat the water before it enters the boiler. The following figures show the quality of water and results of treatment in a plant operated by the Kern Trading and Oil Company.

Untreated water.	Grains per U. S. gallon
Calcium carbonate	6.74
Magnesium carbonate	3.70
Calcium sulphate	10.88
Magnesium sulphate	6.08
Silica	3.93
Oxides of iron and aluminum	0.26
Alkali carbonate, alkali sulphate and chloride	53.03
Total solids	84.62
Total non-incrusting	53.03
Total incrusting	31.59

Results of treatment at various temperatures were as follows:

	Untreated water	185° F. No soda ash	200° F. No soda ash	180° F. excess	Slight soda ash	206° F. soda ash
Non-incrusting	53.0	50.6	52.0	------------	71.1	91.5
Incrusting	31.6	27.5	22.5	------------	12.0	2.4
Total solids	84.6	78.1	74.5	------------	83.1	93.9

The non-incrusting solids can be blown out of a boiler while the incrusting solids have to be scraped or chiseled out. The scale from such water as above is about two thirds gypsum.

Results with varying amounts of soda ash, under a constant temperature, were as follows:

Temperature 206° F.—Soda Ash in pounds per 1,000 gallons.

	Pounds ash		
	1.2	1.6	3.2
Incrusting	18.0	12.0	6.5
Non-incrusting	53.7	61.0	70.5
	71.7	73.0	77.0

Results similar to those above are obtained by treatment in various kinds of heaters in which steam heats the water while the soda ash solution is being added.

Cost of installation of such plants varies from $6.00 to $9.00 per boiler horsepower. For instance, five 80 horsepower boilers would need a plant costing about $3,600. The cost of operation would be only for the soda ash, about 100 pounds per day (at 1¾ to 2 cents per pound). Installation of plants for treatment of boiler water is undoubtedly an economical proposition.

Cost at a plant where no treatment is made except boiling and aerating is indicated by the following: An account on 75 boilers, for five months, showed a daily repair cost, on each, as follows:

Labor	$2 57
Material	1 53
Total	$4 10

Tubes lasted about seven months, and the shells have been in service about four or five years.

STEAM POWER PLANTS.

Cost of a central steam plant to pump eight wells. Estimate based upon past experience by a large operator.

First Cost.

Three 70 horsepower boilers, erected	$4,859 00	
Buildings	1,500 00	
Station piping, auxiliary equipment	3,359 00	
Fuel and water tanks	--------	
Pipe line—complete	1,980 00	
Engines (included in drilling cost), $2,400	--------	
		$11,698 00

Annual Charges.

Interest and Depreciation.

Interest on $10,874 at 6 per cent	$652 44	
Depreciation on boiler equipment, 3 per cent compound interest 5 years	915 28	
Depreciation on station piping, auxiliary equipment, 3 per cent compound interest, 10 years	293 13	
Depreciation pipe lines, 3 per cent compound interest, 10 years	162 73	
Depreciation on engines, 3 per cent compound interest, 10 years	209 37	
Depreciation on buildings, 3 per cent compound interest, 10 years	130 83	
		2,363 78

Operating Expenses per Year.

Two station attendants	$2,160 00	
Two oilers	1,800 00	
Oil waste and packing	345 00	
Water at 2½ cents per barrel	2,248 56	
Fuel, 9,993.6 barrels per year at 15 cents per barrel	1,499 04	
Ordinary repairs to boiler	485 00	
Ordinary repairs to engines	240 00	
Ordinary repairs to pipe lines	198 00	
Ordinary repairs to buildings	75 00	
Ordinary repairs to auxiliaries	167 95	
		9,218 55

Actual monthly operating and repair costs at several steam plants is shown by the following figures, which are in the first two cases averages from annual accounts. The operator furnishing these figures states that in pumping wells from 20 to 30 horsepower (boiler rating) is necessary per well. The power consumption depends upon length of steam lines, or in other words, the distribution of wells.

Monthly Cost of Operation and Repairs, Steam Power Plants.

(Averaged from one year's operation.)

	A		B		C	
	Operation	Repairs	Operation	Repairs	Operation	Repairs
Pay rolls	$266 35	$25 76	$266 27	$81 05	$272 12	$2 55
Material	32 78	20 07	48 69	28 19	16 40	2 08
Store and miscellaneous	1 67	2 97	2 61	1 50	1 31	17
Teaming	1 13	2 13	2 32	4 92	2 19	46
Fuel oil	11 34	----------	303 10	----------	----------	----------
Shop	----------	3 30	----------	13 45	----------	----------
Totals	$313 27	$54 23	$622 99	$129 11	$292 02	$5 26
	$367 50		$752 10		$297 28	

A. Four 70 horsepower 125 pound horizontal return tube boilers.
B. Two 77 horsepower Sterling water tube, and one 100 horsepower internally fired boiler.
C. Four 100 horsepower internally fired boilers.

Pumping Wells by Steam.

Daily cost of operation per well.

(Five wells—2,000 feet deep.)

Labor	$0 28
Fuel (at 50 cents)	60
Oil and waste	05
	$0 93

Daily cost of repairs.

Labor and material depreciation	$0 75

As previously stated, steam equipment of wells is accounted for in the drilling operations.

GAS.

Gas, when plentiful, is the cheapest source of power in the oil fields. Unless used on the property it is usually wasted and therefore its cost is nil.

Pumping by gas power in the Coalinga field is usually accomplished without a central power plant. The gas is collected by means of gas traps from such wells as are able to furnish it and piped to the various engines at each pumping well.

Engines vary from 25 horsepower to 45 horsepower and are either ignited by hot tubes or magneto (the latter being most efficient). At best the engines are mechanically inefficient, due to small load.

The following figures on first cost are from an operator's account on three 1,000-foot wells yielding 17° Baumé oil.

Cost of Gas Equipment (Single Well).

25 horsepower Ideal gas engine and clutch	$810 00
Gas lines (installed)	260 00
Labor and material (installing)	230 00
Corrugated iron housing	60 00
	$1,360 00

A similar account by another property amounts to $1,277.

Another estimate by an operator having about 20 wells, about 2,500 feet deep, is $2,600 per well.

	3 wells 1,600 feet deep	11 wells 2,000 feet deep
Daily cost of operation.		
per well.		
Labor (pumpers)	$1 21	$0 64
Oil, waste, packing, etc.*	09	27
	$1 30	$0 91
Daily cost of repairs and renewals.		
per well.		
Labor and material	$0 48	$0 27
Depreciation (15 years)	25	23
	$0 73	$0 50

Gas Engine Operating Cost.

Operation, 63 engines, 18 months.

Machine shop	$0 156	per engine day
Labor attending	329	per engine day
Calumet oil	157	per engine day
Castor oil	023	per engine day
Hot tubes	013	per engine day
Total	$0 678	

An engine uses about 4,000 cubic feet per day while pumping, according to Mr. Thomas Cox, and 600 cubic feet per hour while pulling rods or tubing.

Analysis of Gas from Three Neighboring Wells in the West Side, Coalinga Field.

	%	%	%
Higher hydrocarbons as propane (C_3H_3)	Nil	Nil	Nil
Hydrogen (H)	Nil	Nil	Nil
Methane (CH_4)	77.6	84.6	61.8
Illuminants (C_2H_4, etc.)	.4	.3	.7
Carbon dioxide (CO_2)	20.3	13.8	34.2
Carbon monoxide (CO)	Trace	.5	.9
Oxygen (O)	.3	Nil	.3
Nitrogen (N)	1.4	.8	2.1
Total	100.00	100.00	100.00
British thermal units per cubic foot, water uncondensed	795	866	633
British thermal units per cubic foot, water condensed	833	908	633

---

*Some operators report oil at 20 cents per day.

ELECTRICITY.

Pumping by electricity is accomplished by individual motors and a central transformer plant. The following is an estimate on a plant to continuously pump eight wells and was made for comparison with the previous figures on a central steam plant, by the same operator.

Electrical Equipment, First Cost.

Based on transformer capacity for ten wells, any two of which may have the necessary work required to maintain an oil well such as "rods and cleaning out jobs" performed on them without interference with operation of the other eight wells in group.

Three 25 kilowatt $\frac{6600}{440}$ volt transformers	$769 95	
Eight complete electrical equipments, each equipment consisting of one type "F" variable speed 10-pole induction motor equipped with 10 and 20 inch pulleys, change-over switch, controller, no voltage circuit breaker, controller case, counter shaft and belt	5,667 64	
Line and motor wiring	830 16	
Contingencies, motor shed, etc.	737 25	
Total		$8,005 00

Annual Charges.

Interest and Depreciation.

Interest on $8,000 at 6 per cent	$480 00	
Depreciation on motors and auxiliary equipment, 3 per cent compound interest 10 years	493 80	
Depreciation on line and motor wiring, 3 per cent compound interest 10 years, including contingencies, motor sheds, etc.	119 57	
Depreciations on transformers, 3 per cent compound interest 10 years	67 16	
		1,160 53

Operating Expense.

1 motor tender and lineman	$1,500 00	
2 oilers	1,000 00	
Oil and waste	200 00	
Ordinary repairs to motor and auxiliary equipment	566 26	
Ordinary repairs to line and motor wiring	41 50	
Ordinary repairs to transformers, 10 per cent	76 99	
Electric current at 1.2 cents per kilowatt hour	3,752 00	
		7,136 75

Another set of figures from accounts of an operator having 17 wells about 1,600 feet deep, oil 17° Baumé, is as follows:

Cost of electrical equipment (single well) 10 to 30 horsepower.

Westinghouse variable speed motor and sliding base	$537 00
Power line and motor wiring, controller, resistance frames, material and labor	367 00
Transformers	116 00
Labor, installing, hauling and material	41 00
Counter shafts and sliding bases, bearings, pulleys	98 00
Corrugated iron housing	53 00
	$1.212 00

Daily cost of operation by electricity per well.

Labor, pumpers	$1 04
Power at 1 cent per kilowatt hour	83
Oil, waste and packing	05
	$1 92

Daily cost of all repairs per well.

Labor and material	$0 14
Depreciation (15 years)	22
	$0 36

Comparison of the above figures can not be accurately made as operating conditions at various localities are so different, particularly the number of wells attended by one man (5 to 10); however the figures reduced nearly to a common basis would be as follows:

Pumping Power. Comparative Cost per Well.

	Steam	Gas	Electric	
First cost	$1,358 estimate	$1,360 actual	$1,000 estimate	$1,212 actual
Fixed charges per day	$.81	$.25	$.39	$.22
Operation and repairs per day	*3.16	1.78	2.71	2.06

Other figures which may be roughly compared with those above are as follows:

At a property with 11 wells, 1,300 feet deep, averaging 30 barrels per well day, 15° Baumé oil, accounts for five months (153 days) show the following field expense not including superintendence:

Labor	$1 78	per well day
Pump repairs	25	per well day
Well repairs	98	per well day
Electric operations	93	per well day
Sundry	1 36	per well day
Total	$5 30	per well day

Operations, 85 per cent to 90 per cent of total time.
Sand produced averages 5 per cent.

A group of 37 West Side wells, about 1,800 feet deep, and each producing some 70 barrels of 15° Baumé oil per day, costs as follows to operate:

Pumping wells	$1 72	per well day
Repair and clean wells	5 45	per well day
Collecting oil	54	per well day
Miscellaneous	62	per well day
Total	$8 33	per well day

Another operator pumping by steam from a depth of 2,500 feet shows daily expense per well to be about $9.00.

At a group of 24 wells, 2,000 feet deep, gravity 15° Baumé pumped by gas, accounts for ten months, show the following field expense:

Wages	$3 66	per well day
Supplies	5 94	per well day
Repairs	2 64	per well day
Total	$12 24	per well day

Items in these accounts are—

Wages of pumper (10 wells)	$3 50
Wages of repair crew, 1 foreman	4 00
Wages of repair crew, 3 men	3 50

---

*Cost of water and boiler repairs 93 cents per day.

Distribution of labor expense for the repair crew for a period of seven months (214 days) (5,136 hours) was as follows:

Repair of Wells (Labor).

	Number of jobs	Total time	Average time	Per cent operating time lost	Cost per well day
Engines and boilers	235	1,222 hours	5.2 hours	.99	$.067
Rods parted	177	1,153 hours	6.5 hours	.94	.064
Sand and mud	230	2,423 hours	9.5 hours	1.97	.134
Changed seats	4	20 hours	5.0 hours		
Pulling, tubes and rods	310	3,676 hours	11.8 hours	2.99	.204
Miscellaneous	321	2,465 hours	9.8 hours	2.00	.135
Totals				8.89	$.604

Repair costs of course differ with the natural behavior of the wells. At this group where about 5 per cent of the liquid pumped is sand, accounts show that a pump barrel and plunger lasts eighteen days (costing from $11.00 to $19.00 each or 83.4 cents per well day).

A group of 16 wells, 1,600 feet deep, oil 17.5° Baumé, sand .05 per cent or less, shows the following well repair costs:

Labor, pulling and cleaning	$0 88	per well day
Pumps and parts	21	per well day
Tubing	11	per well day
Rods	08	per well day
	$1 28	per well day

Wells in the East Side field do not sand up frequently and pumps last very much longer, one account of 113 wells for a year showing an average of fifty-one days. Rods probably last about three years and tubing from five to ten years.

The reduction of cost when oil is of high gravity and sand does not flow with the oil is illustrated by the following figures presented by a large operator in the East Side field. It will be noted that these figures include overhead expense (superintendence, administration, etc.) which did not appear in the previous accounts.

Production Cost—East Side Field.

Two groups of wells (each 7 wells). For six months. Almost no sand.

	Pumping	Flowing
Depth of wells (average), feet	1,572	2,634
Depth of pumps (average), feet	1,466	2,389
Gravity of oil	21.8°	24.7°
Size pump, five 2″ and two 3″.		
Production per well day, barrels	57	198

	Pumping		Flowing	
	6 months	Per well day	6 months	Per well day
Labor (pumpers, roustabout, enginemen)	$1,815 62	$1.42	$2,142 39	$1.680
Machine shop	299 55	.234	80 84	.063
Teaming	12 25	.009	16 85	.013
General supplies	327 45	.256	361 80	.282
Tubing			71 93	.056
Rods			36 00	.028
Pumps	331 82	.260	24 51	.019
Belts	172 29	.135	106 11	.083
Engine parts	195 87	.153	25 03	.019
Bull ropes	21 54	.017		
Proportion general charges (superintendence, administration)	500 00	.391	300 00	.235
Totals	$3,676 39		$3,165 47	
Average cost per well day		$2.88		$2.48
Average cost per barrel		.05		.012

Another group of ten East Side wells, about 1,600 feet deep and producing 50 barrels per day of 21° Baumé oil, costs as follows per well per day:

Pumping	$1 25
Repair of wells	1 12
Collecting oil	01
Miscellaneous	42
Superintendence	73
Total	$3 53

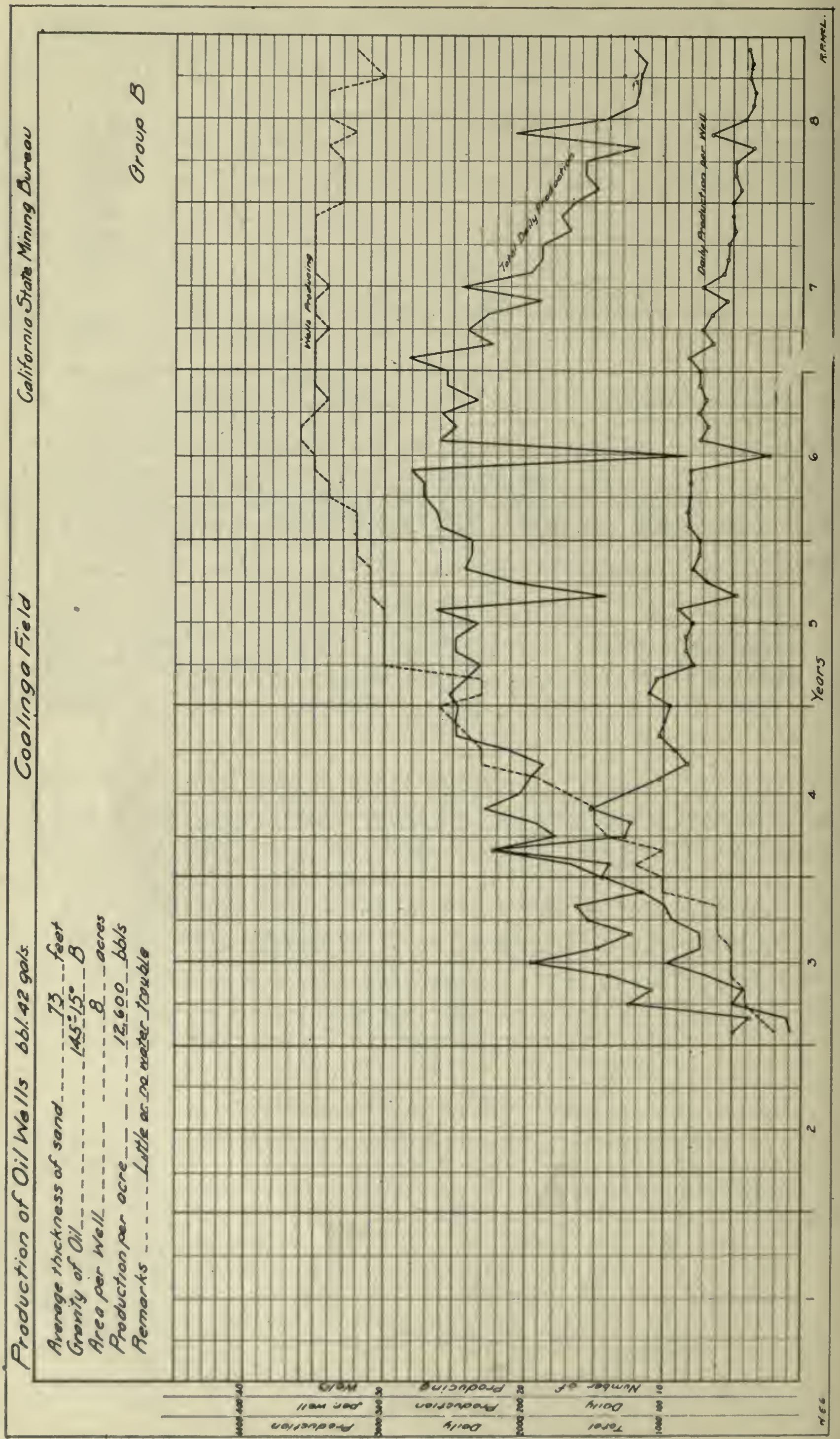


Fig. 8. Production record of 36 wells.

LIFE OF WELLS.

Records of operators for the past twelve years show almost no wells abandoned on account of exhaustion.

There has been considerable theoretical discussion as to productiveness of oil land, in relation to the various observed conditions, few actual figures have however accompanied these discussions. Therefore considerable space is here given to presenting evidence which it is hoped will be carefully studied and discussed by other writers.

The rate of decline in production of wells in the Coalinga Field can be divided into three parts. (1) Rapid initial decline, lasting possibly a year, and averaging at least 20 per cent. (2) Uniform decline extending over about 4½ years and amounting to about 60 per cent. (3) Nearly stable production lasting an unknown period (possibly 7 to 10 years), during which the rate of decline is very slow until the well is exhausted, or becomes unprofitable.

Information underlying a general statement, such as that made above, is not complete. The question is important in estimating future operations and the data at present available is here presented in the form of diagrams showing the behavior of some thirty groups of wells which have been producing for 5 or 10 years. The diagrams are made up from monthly reports and show, number of wells producing, total production per day and average production per well per day. The figures for total production are fairly accurate, being obtained from the monthly production statements. The number of producing wells is subject to slight errors, but represents operations fairly well.

Special thanks are due to Mr. R. W. Dallas who assisted in obtaining the information upon which many of these diagrams are based. Careful study of the diagrams will give a good idea of actual working conditions and doubtless other general statements can be made from them.

The line showing daily production per well seems to be most definite and forms the basis for the following table, covering periods where the decline followed a general average.

Groups B, N, Q, Y, and Z illustrate the early portion of the life of an actively developed property, where a regular development campaign has been carried on until a given area has been entirely drilled. The latter portion of property's life, after drilling has ceased, is represented by groups G, I, J, L, R, S, X, AB, AC, AD, and AE.

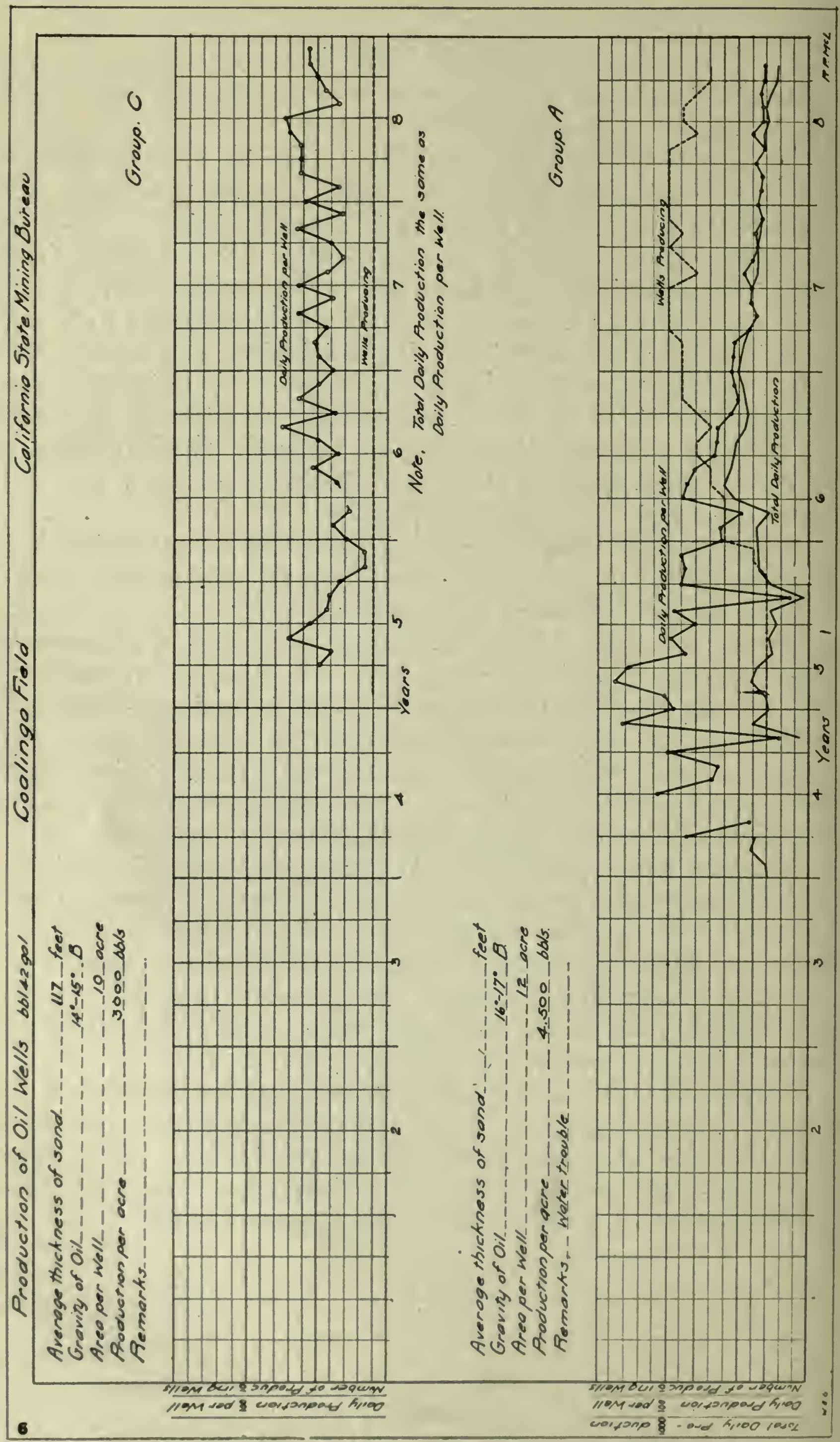


Fig. 9. Production record of 11 wells.

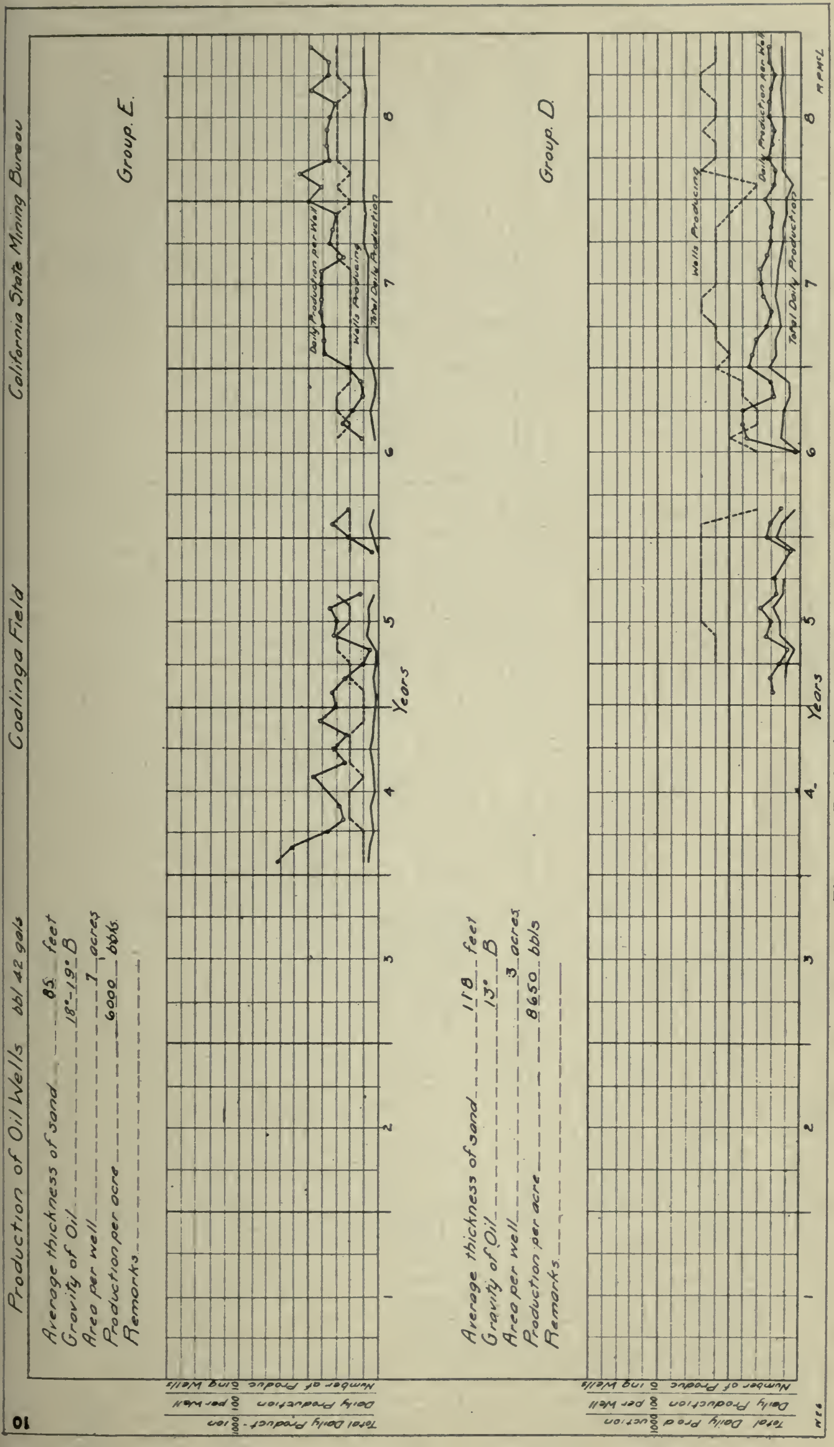


Fig. 10. Production record of 10 wells.

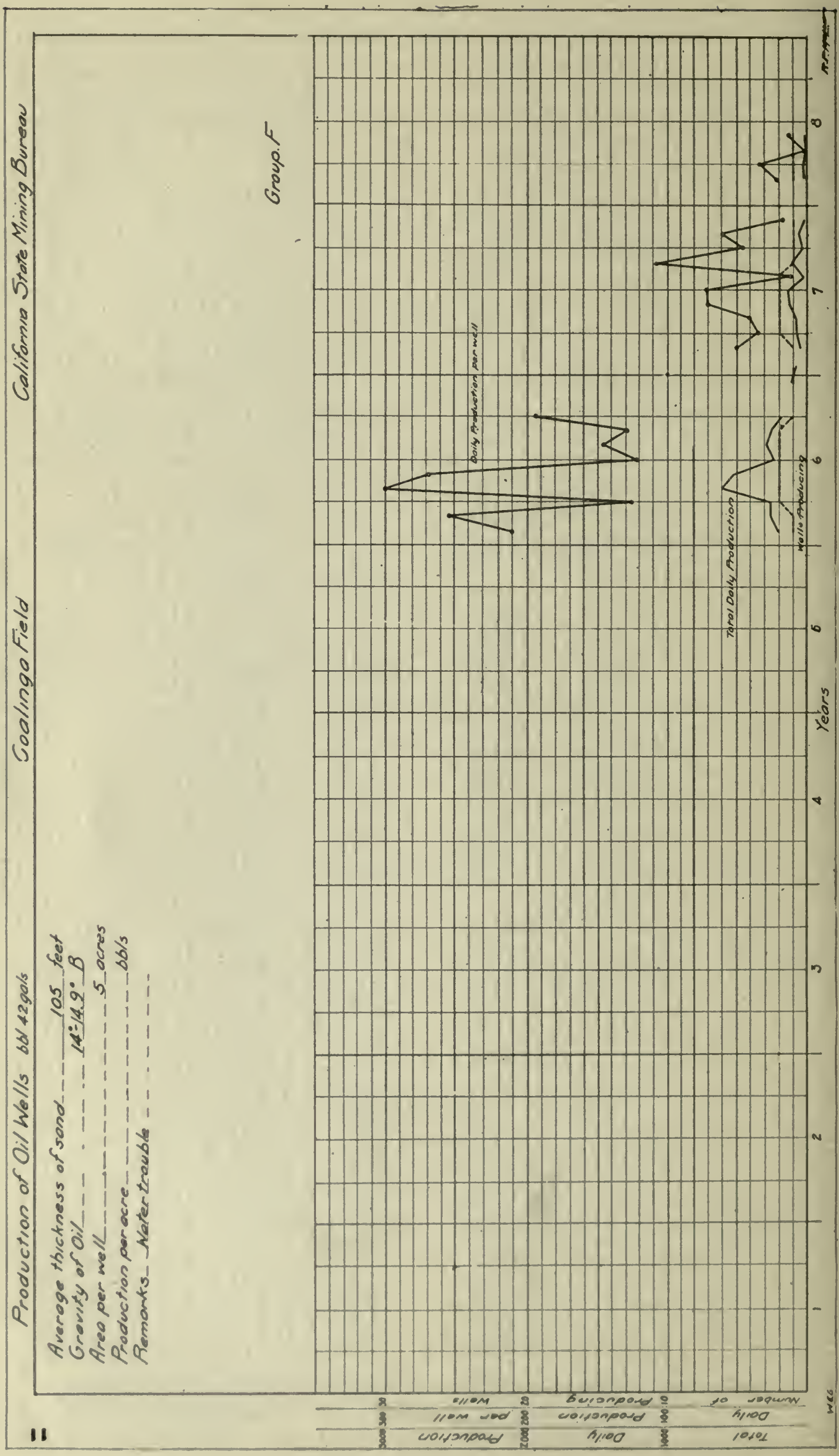


Fig. 11. Production record of 2 wells.

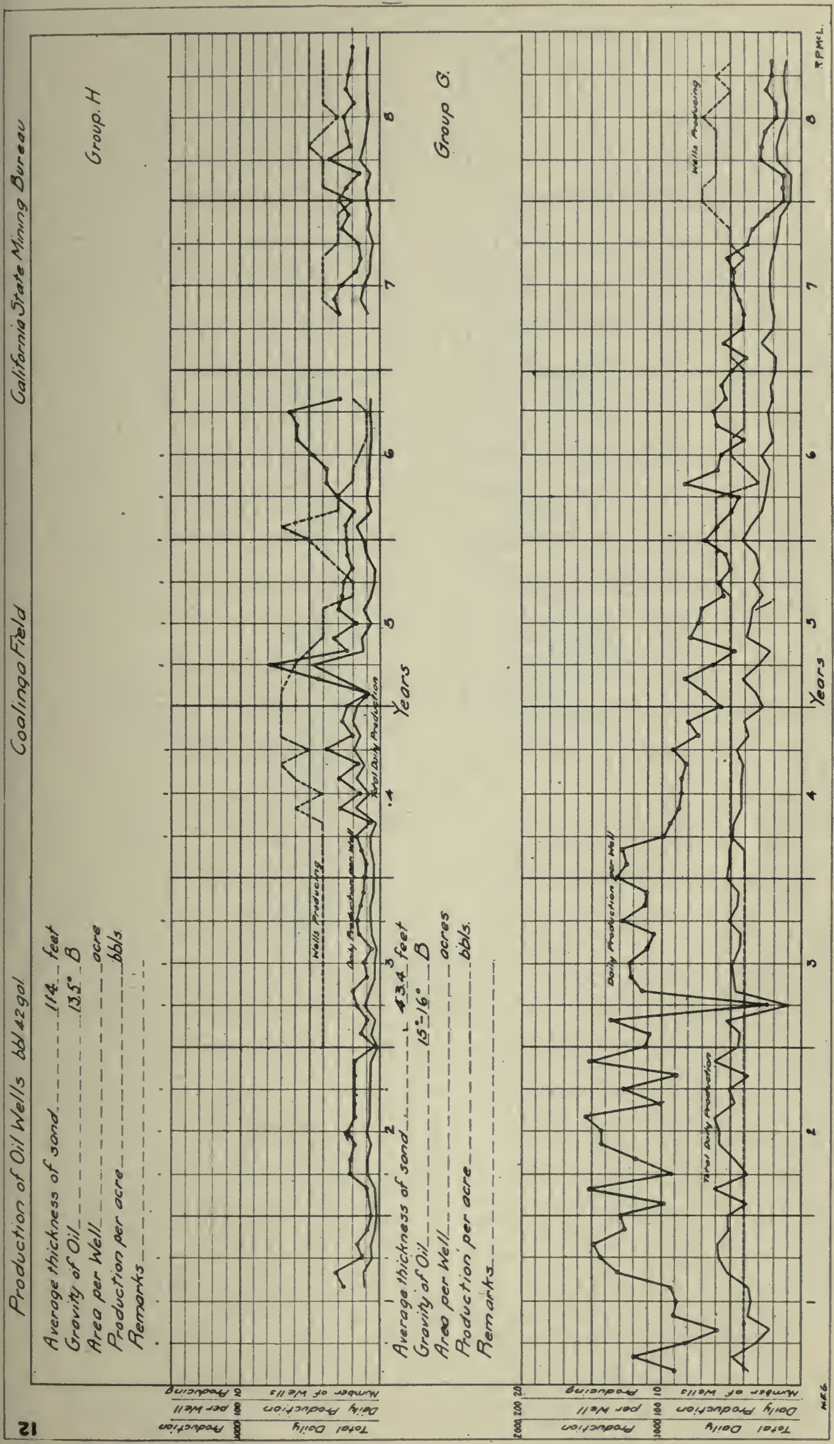


Fig. 12. Production record of 12 wells.

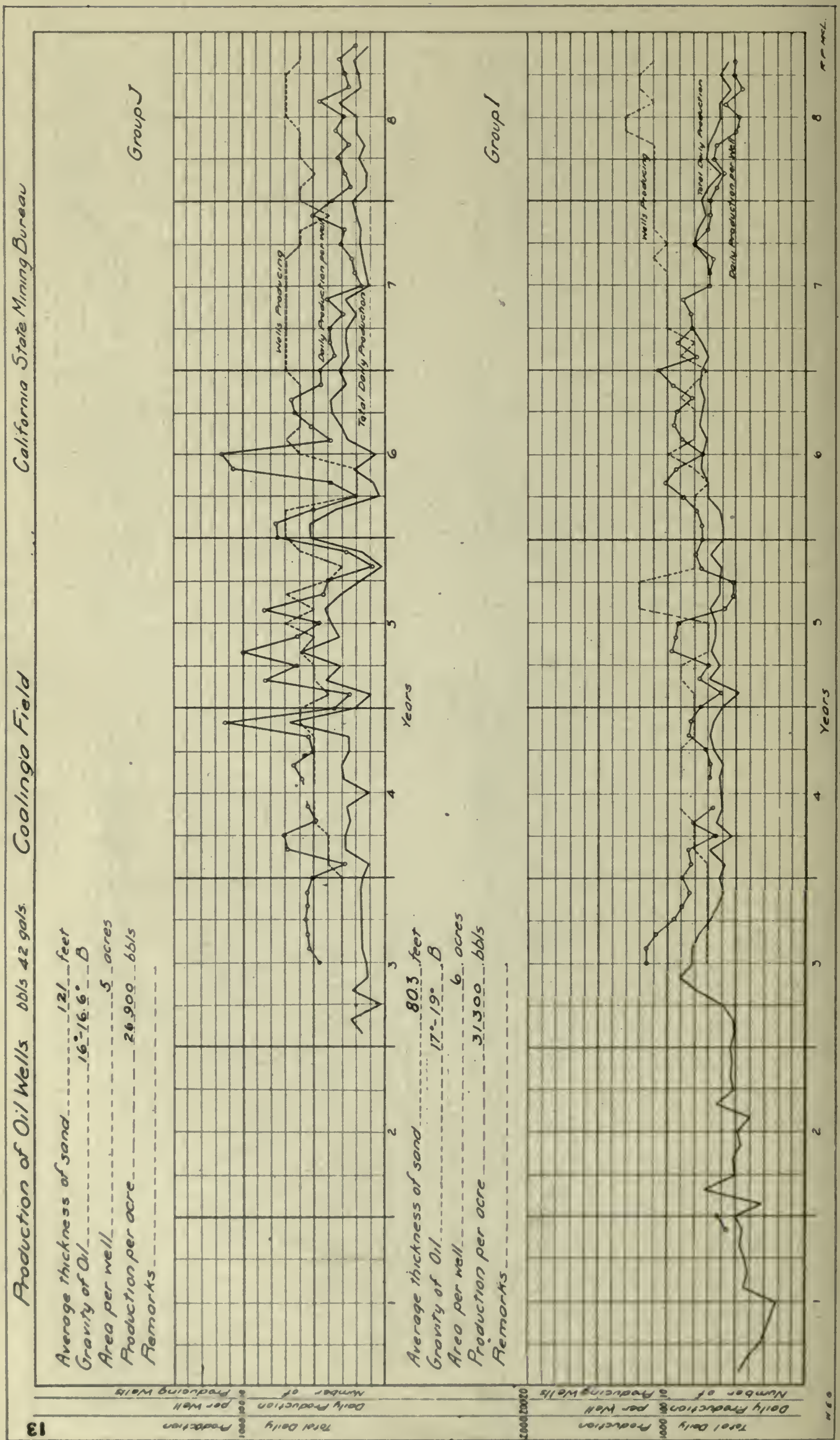


Fig. 13. Production record of 20 wells.

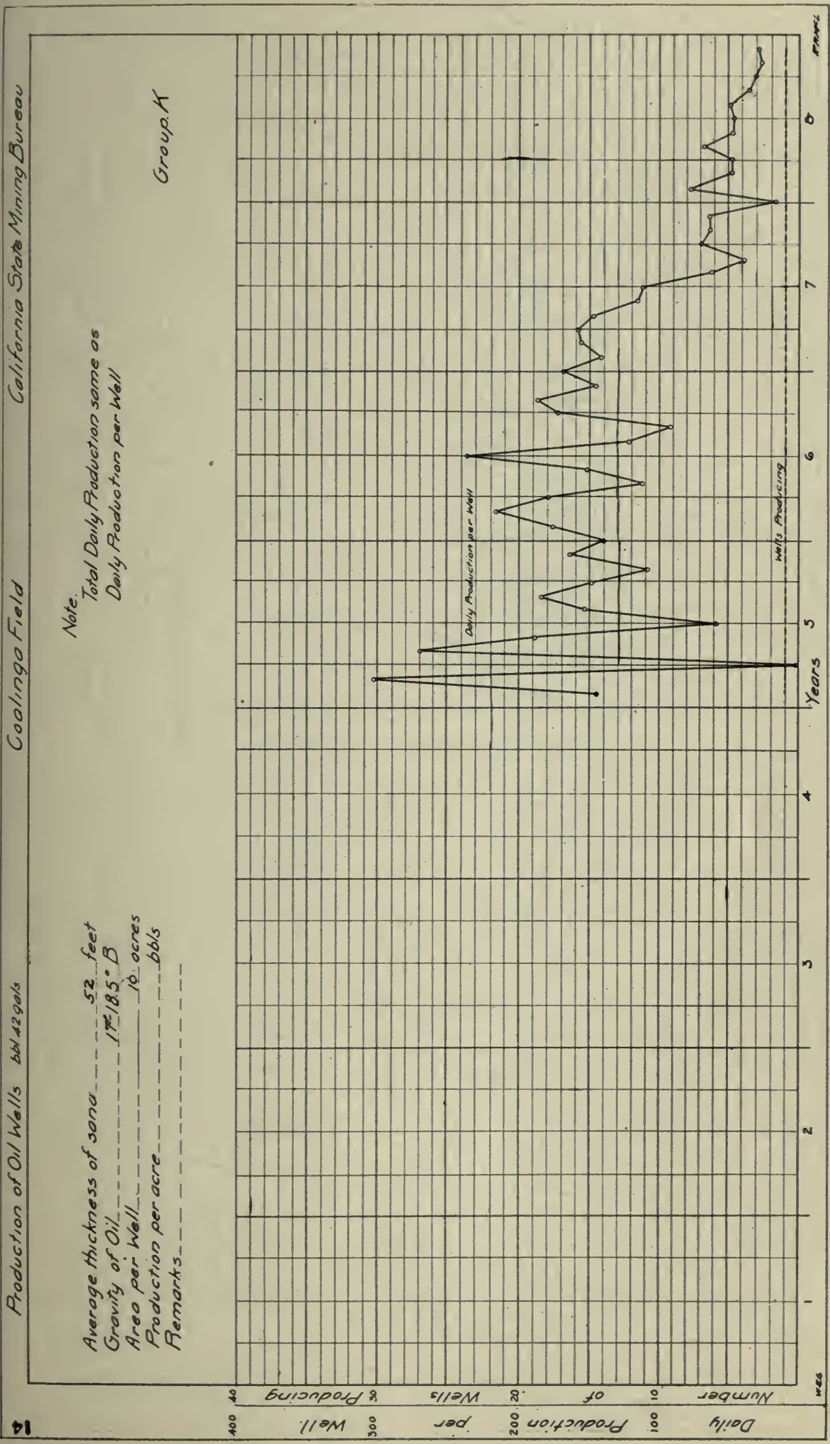


Fig. 14. Production record of 1 well.

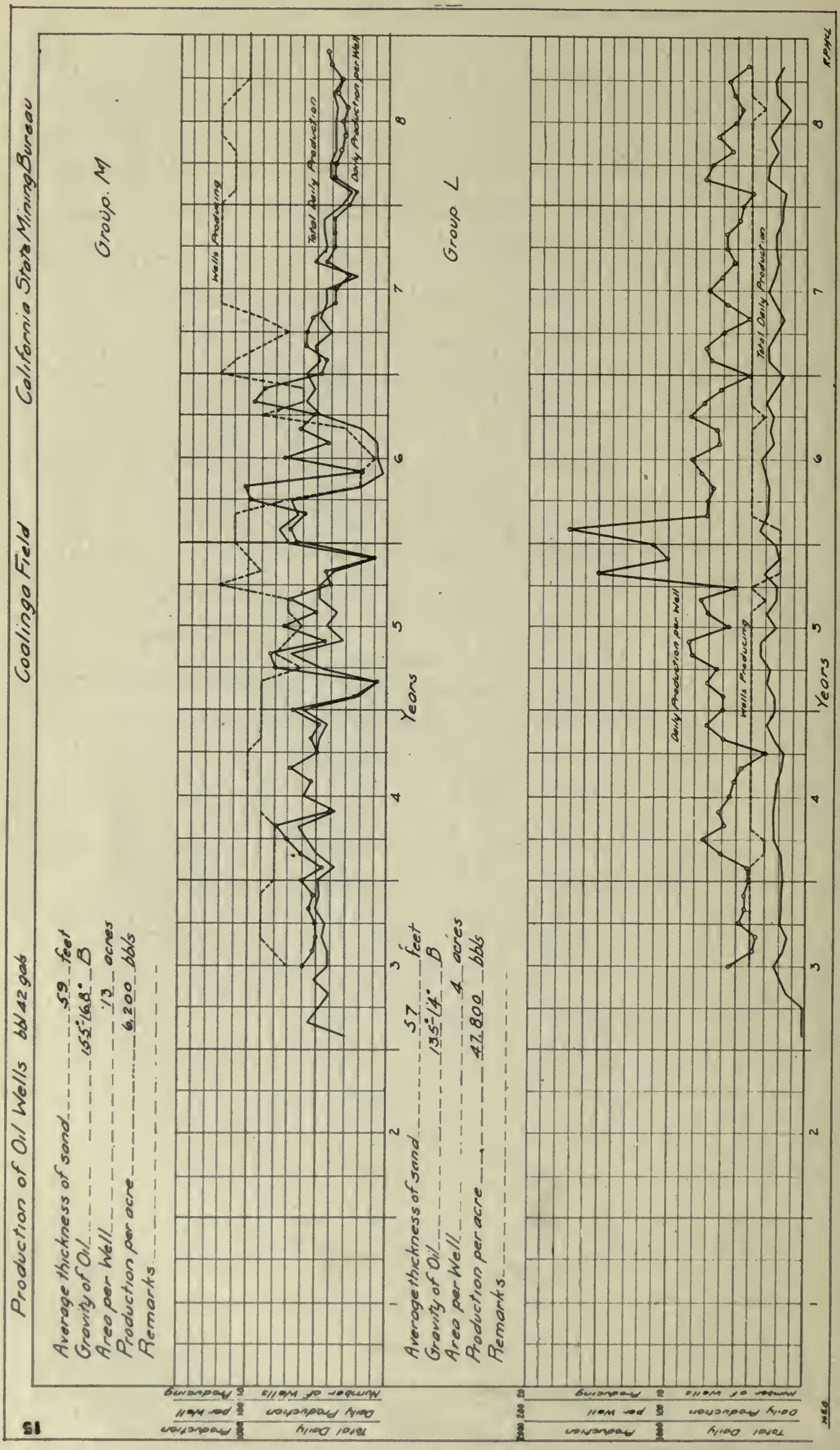


Fig. 15. Production record of 16 wells.

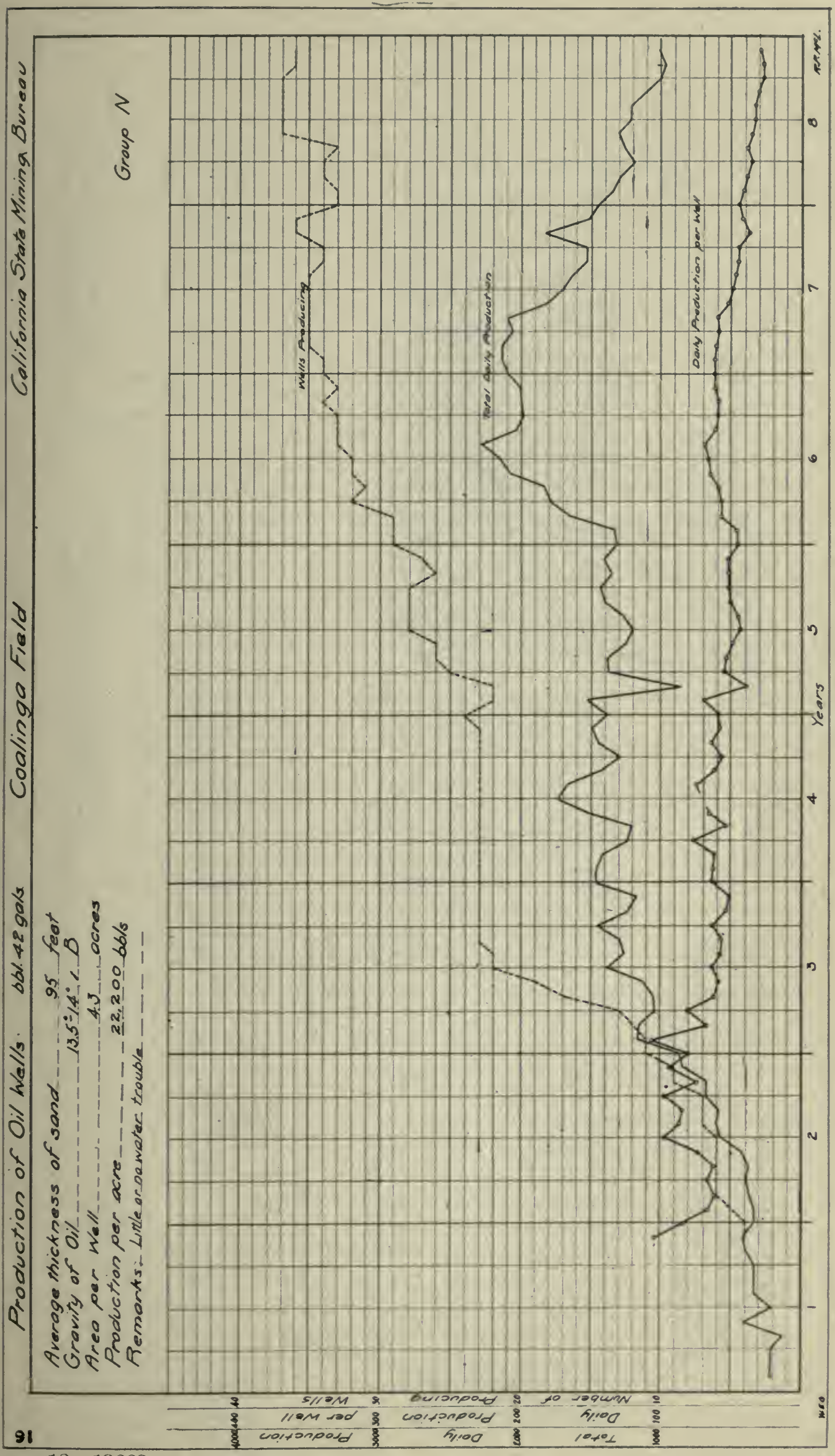


Fig. 16. Production record of 37 wells.

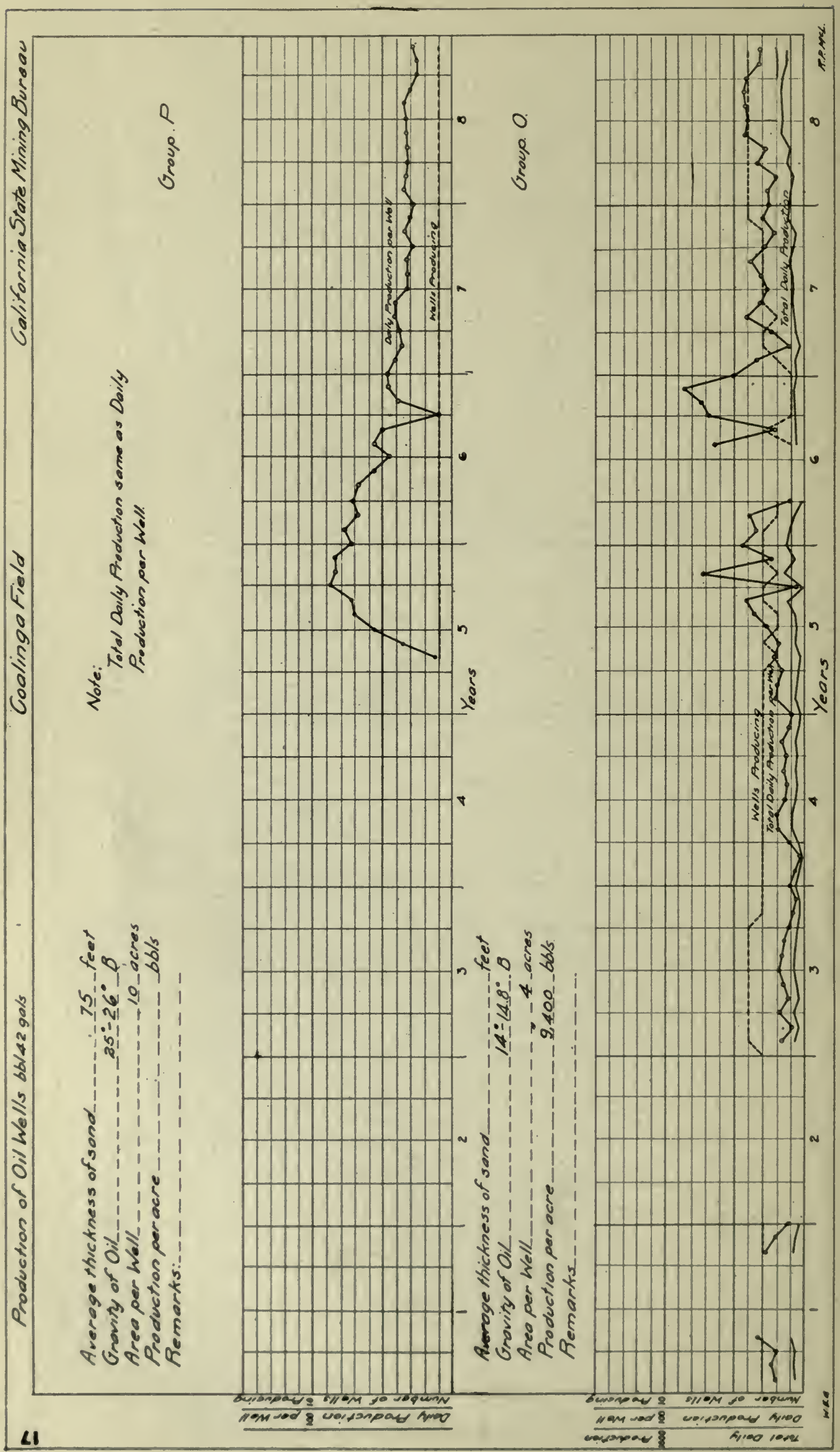
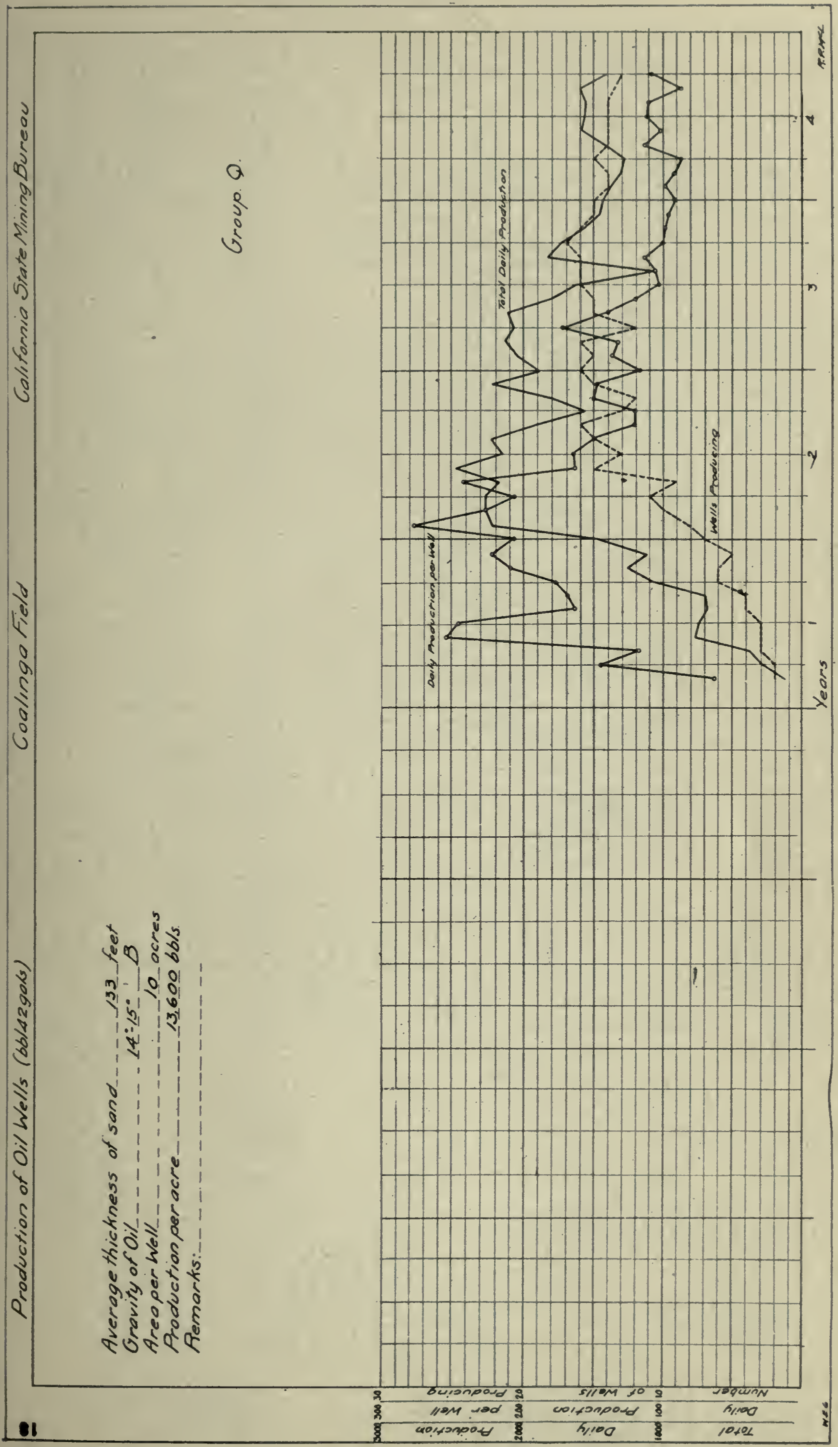


Fig. 17. Production record of 5 wells.



Average thickness of sand 133 feet
Gravity of Oil 14°-15° B
Area per Well 10 acres
Production per acre 13,600 bbls.
Remarks:

Fig. 18. Production record of 17 wells.

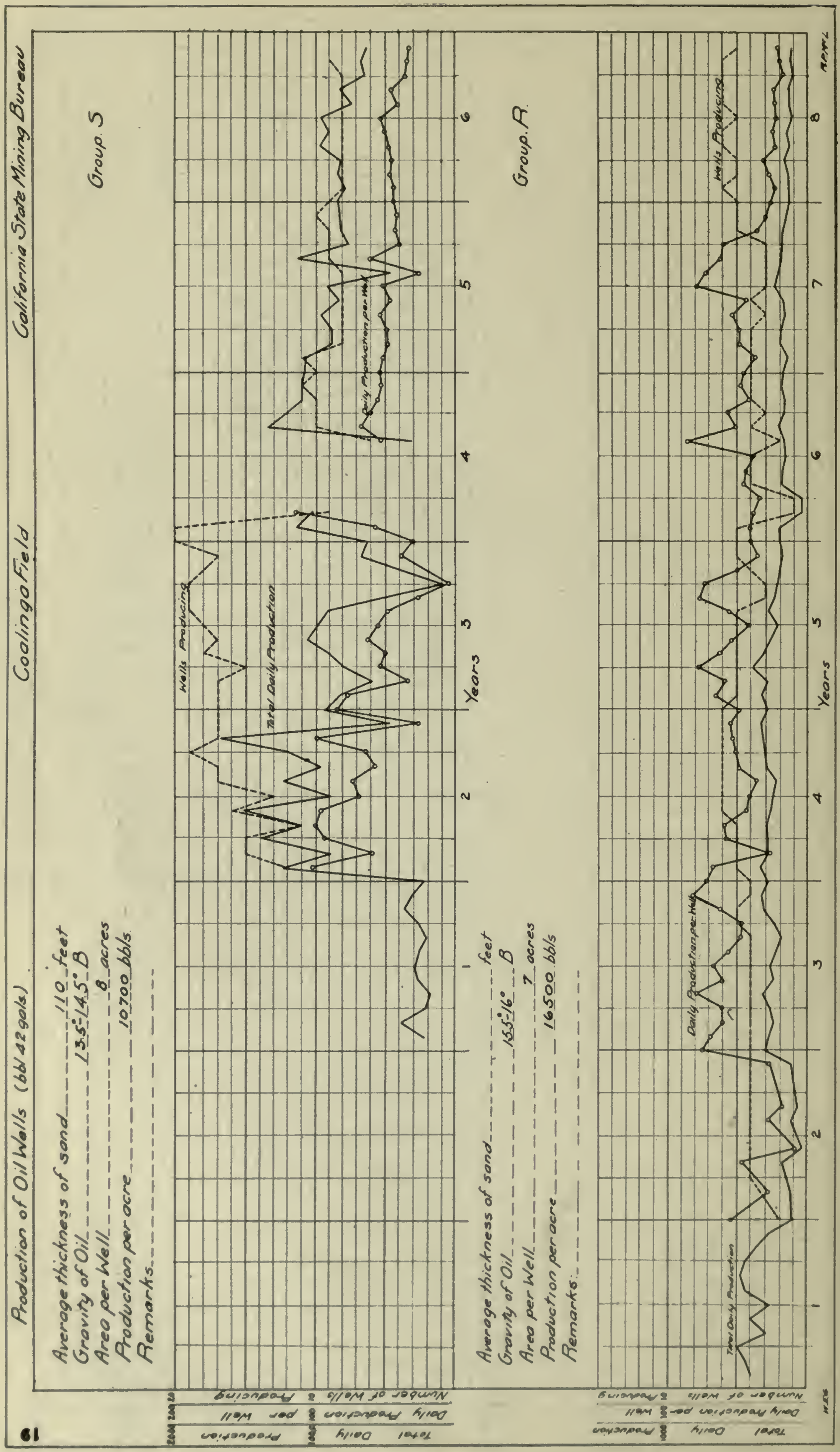
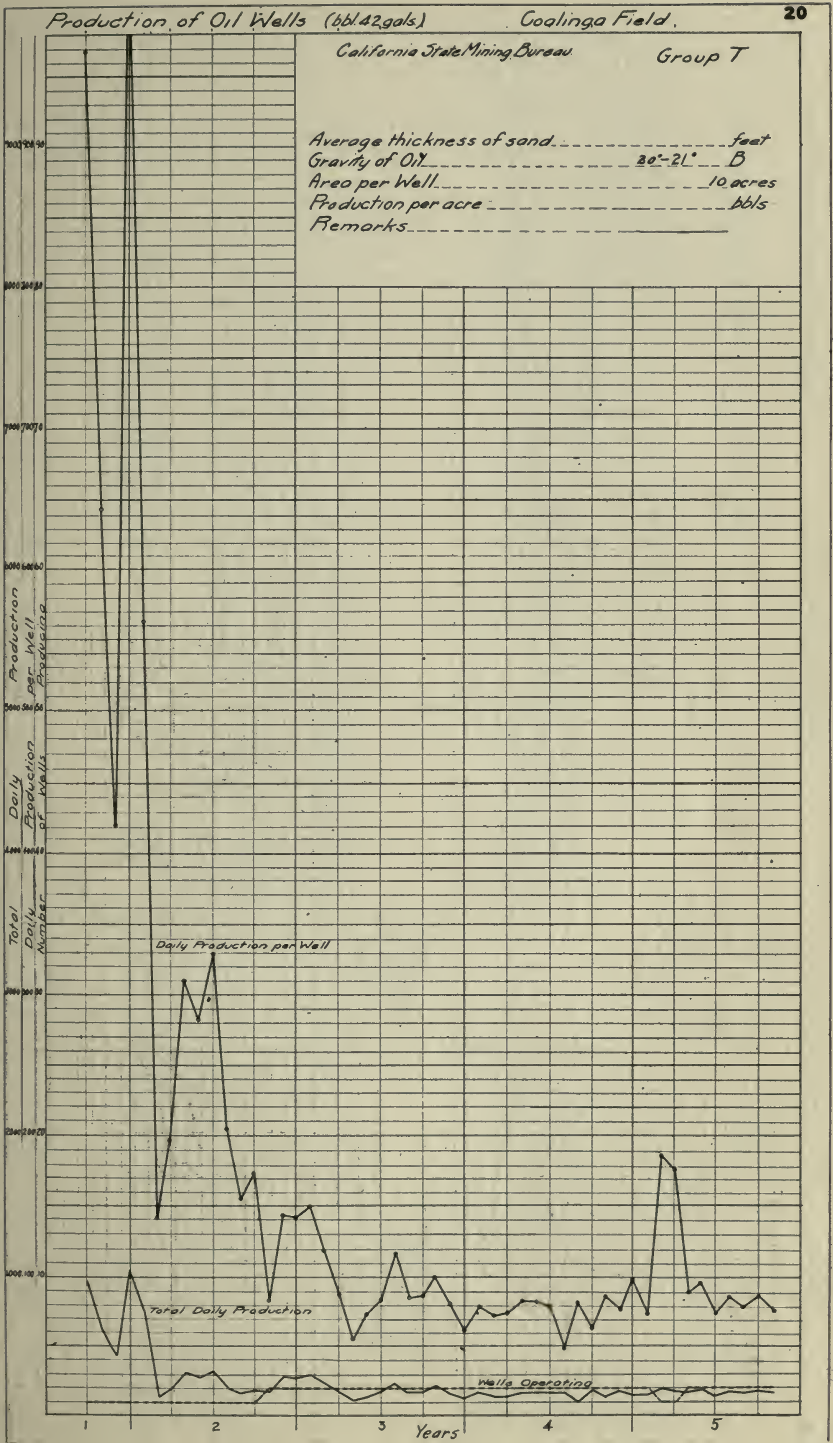


Fig. 19. Production record of 26 wells.



Production of Oil Wells (bbl. 42 gals.) Coalinga Field. **20**

California State Mining Bureau. Group T

Average thickness of sand _______________ feet
Gravity of Oil _______________ 20°-21° B
Area per Well _______________ 10 acres
Production per acre _______________ bbls
Remarks _______________

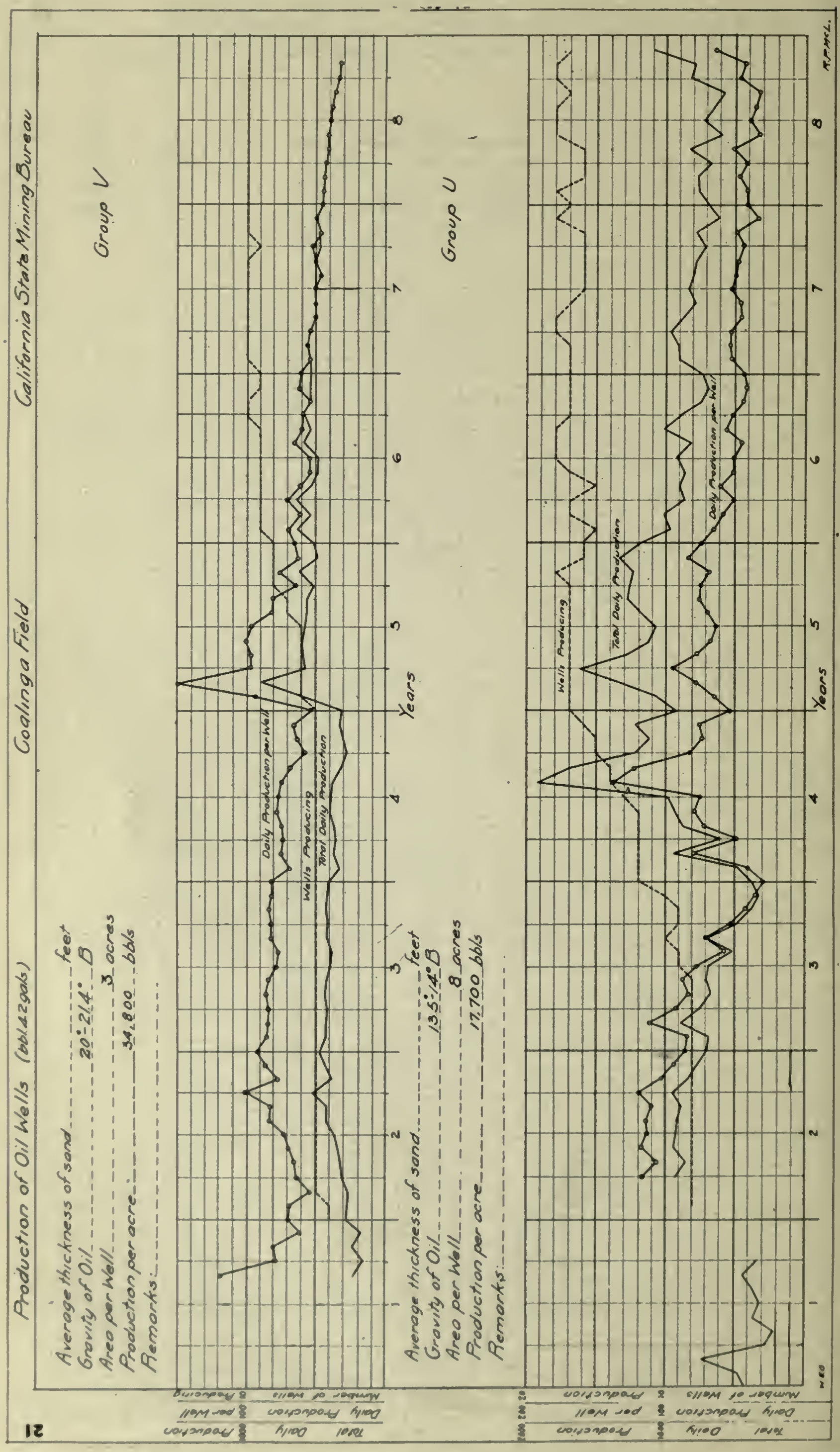


Fig. 21. Production record of 28 wells.

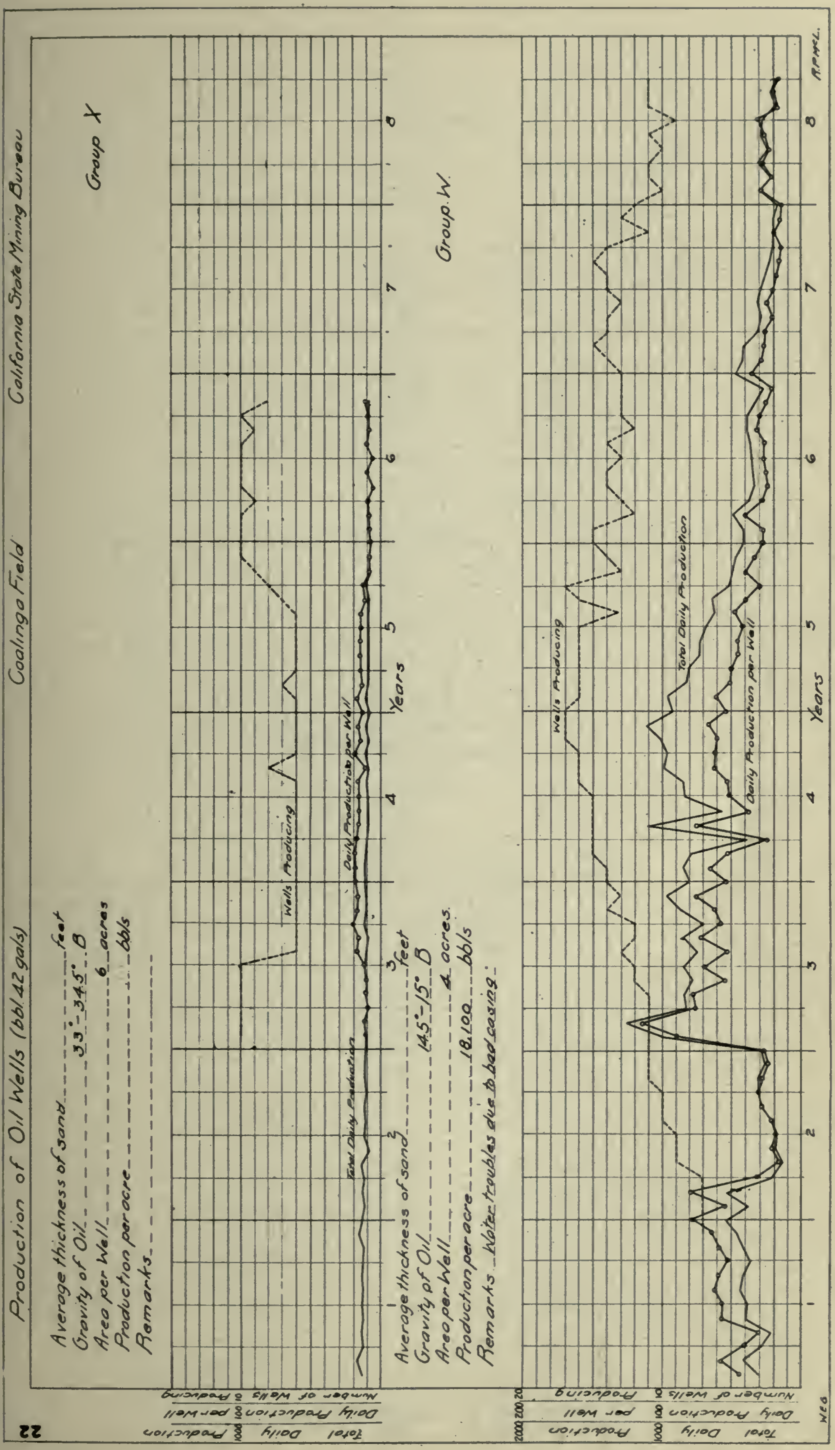


Fig. 22. Production record of 27 wells.

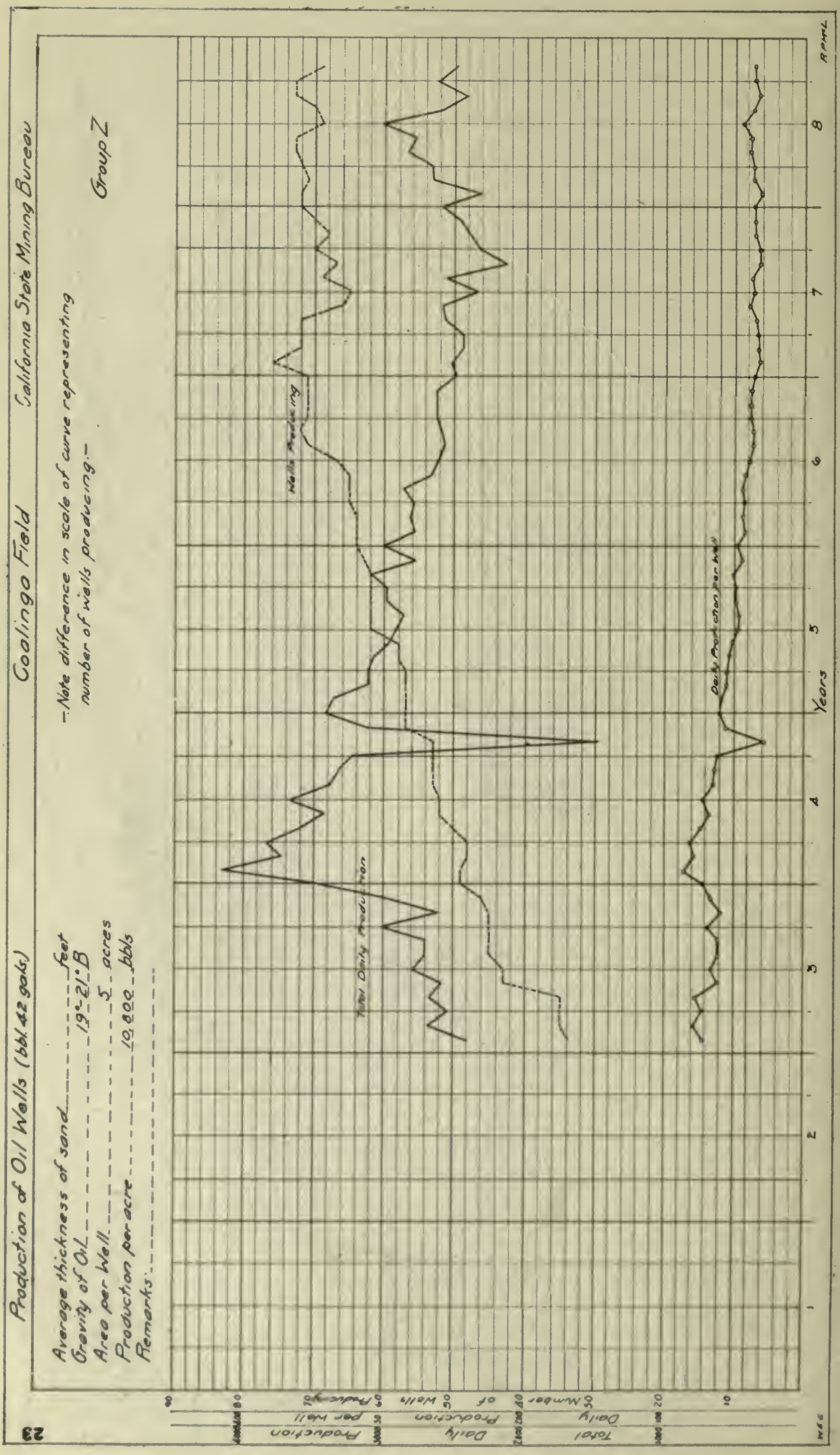


Fig. 23. Production record of 76 wells.

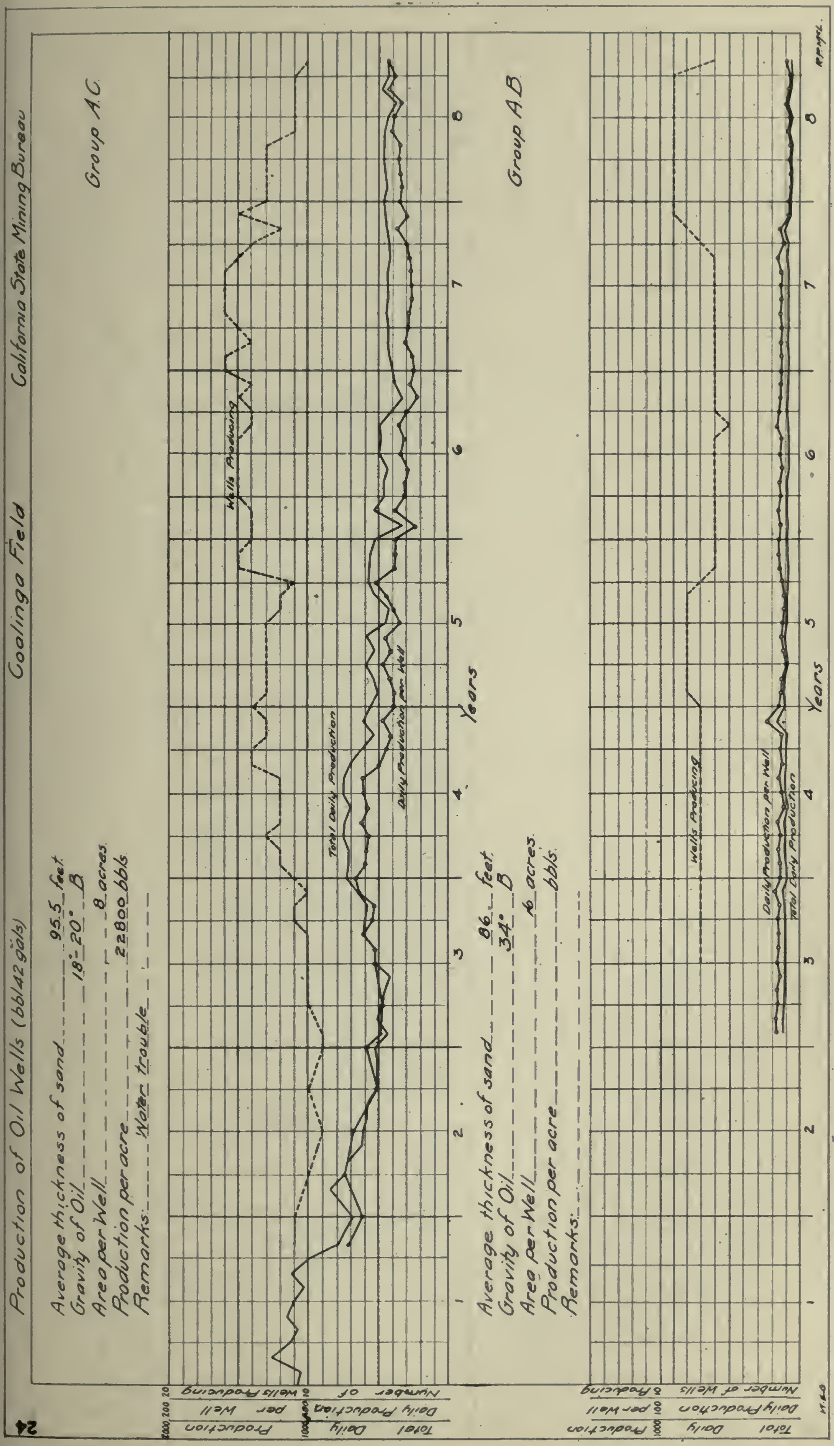


Fig. 24. Production record of 25 wells.

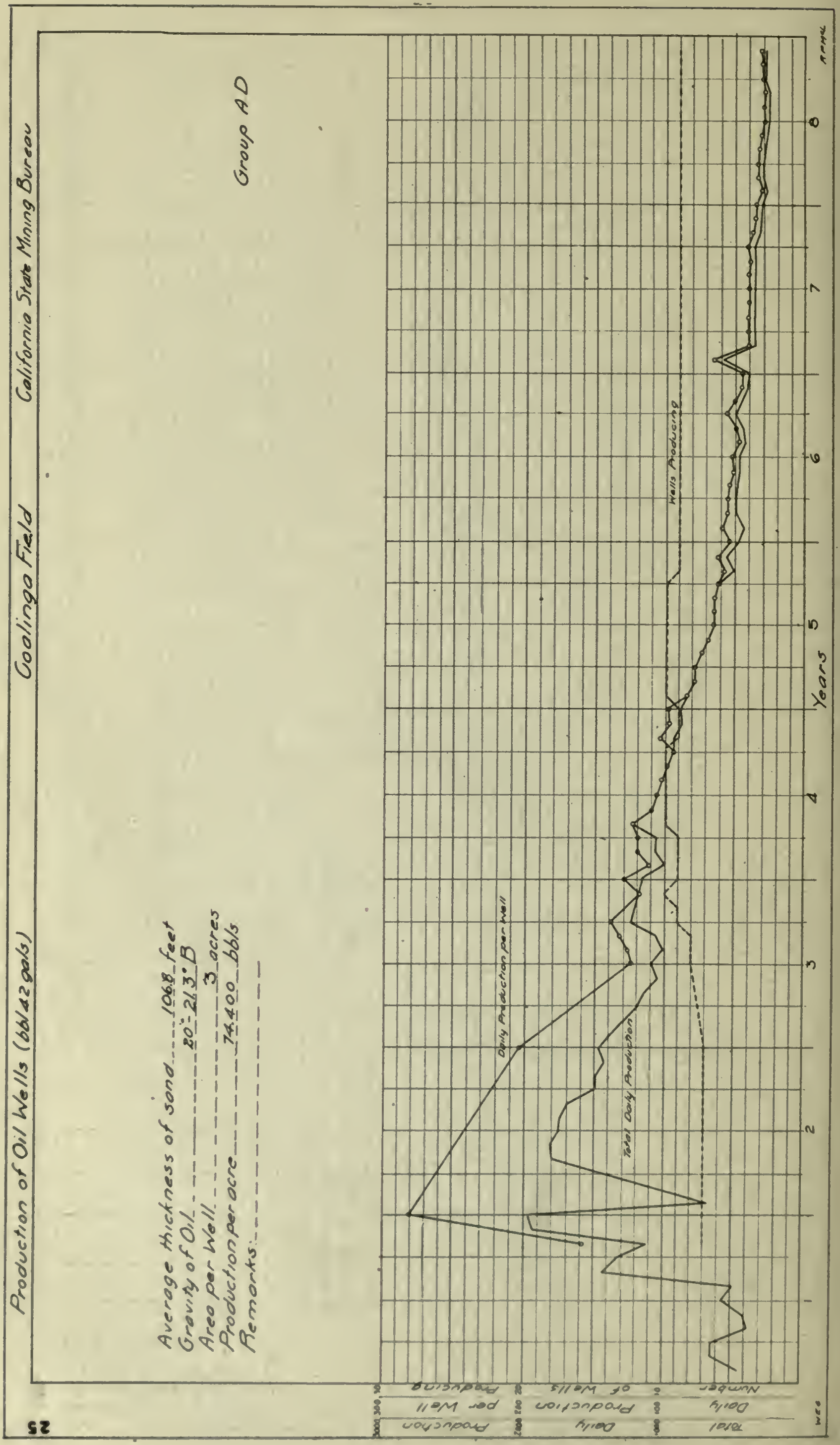
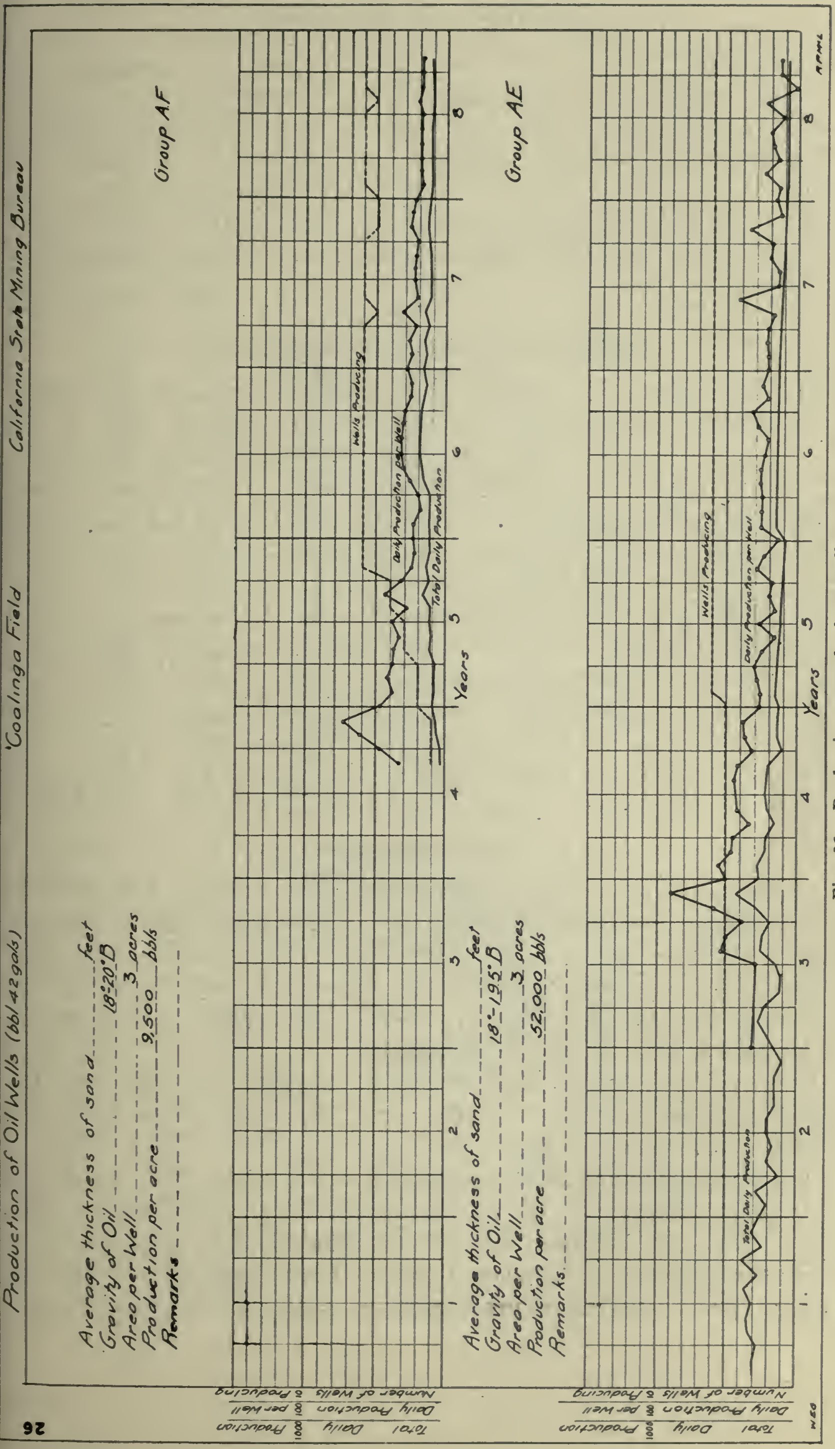


Fig. 25. Production record of 10 wells.



Average thickness of sand .... feet
Gravity of Oil .... 18°-20° B
Area per Well .... 3 acres
Production per acre .... 9,500 bbls
Remarks ....

Average thickness of sand .... feet
Gravity of Oil .... 18°-19.5° B
Area per Well .... 3 acres
Production per acre .... 52,000 bbls
Remarks ....

Fig. 26. Production record of 12 wells.

Summary of Production Diagrams.

Group	Gravity	Acres per well	Number of wells	Period of gradual decline	
				Number of months	Loss (barrels) monthly
A	16	12	10	52	1.6
B	15	8	35	51	1.13
C	14	10	1	----------	----------
D	13	3	7	30	----------
E	19	7	3	60	----------
F	15	5	1	----------	----------
G	16	----------	----------	84	1.45
H	14	----------	4	----------	----------
I	18	6	11	61	.82
J	17	5	7	58	.53
K	19	10	1	46	3.85
L	14	4	4	41	1.15
M	17	13	12	45	.82
N	14	4	37	78	.67
O	15	4	4	----------	----------
P	26	10	1	29	.69
Q	15	10	17	27	2.0
R	16	7	6	72	.71
S	15	8	10	29	.93
T	21	10	2	----------	----------
U	14	8	18	57	.70
V	21	3	10	39	1.18
W	15	4	17	65	.74
X	34	6	10	----------	----------
Y	21	5	23	69	1.0
Z	20	5	73	70	.54
A B	34	6	9	69	.116
A C	20	8	15	84	.49
A D	21	3	10	21 41	4.48 .83
A E	20	3	6	64	.55
A F	19	3	6	46	.48

CONCLUSIONS.

Uniform rate of decline in average daily well production is observed in 24 groups. Maximum length of time, during which decline was uniform, 84 months; minimum 27; average 54. Rate of decline, maximum 4.48 barrels per month, minimum 0.11 barrels, per month, average .99 barrels per month. 11.9 barrels per year. The average decline for the entire field is only .52 barrels per month.

Seven of the diagrams show almost no decline. They are from the oldest properties in the field and form the basis of the statement relative to the period of stability.

The irregularities of these diagrams show the impossibility of making an accurate estimate of the amount of oil in a piece of undeveloped land. They also illustrate some of the difficulties in outlining a development campaign. However, they do fairly agree in showing the average rate of decline in production of wells and indicate a corresponding rate at which new wells would have to be drilled to maintain a uniform production.

Some of the groups (A, N, Q, U, V, W, Y, and Z) show periods of time ranging from two to three years during which production was maintained. During these periods the number of producing wells was increased at a rate of a little over 1 per cent (minimum .8, maximum 3.0, average 1.7) per month, which agrees closely with the figure for rate of decline of wells.

The diagrams apparently fail to establish any very definite relation between productiveness and such natural conditions as gravity and thickness of sand.

WATER IN COALINGA OIL WELLS.

The following information was published in a preliminary report issued early in 1914, with the view to arousing public interest in the subject of protecting the oil sands from water:

Briefly stated, the oil sands of Coalinga are from 100 to 400 feet total thickness, lying in the form of more or less continuous sheets or strata which extend over a proven area approximately fifteen miles long and two miles wide. The several sands making up the total thickness are separated by clay beds from 10 to 50 feet in thickness. The dip of these formations varies from 20 to 40 feet per 100. Over 1,000 wells are producing at depths varying from 700 to 4,000 feet. The wells cost from $4,000 to $70,000 each. Similar to those beds carrying the oil are others bearing water. These water sands are sometimes above, below and between the oil sands. When water and oil sands are both penetrated by a well the water enters the oil sand. The water frequently forces the oil back into the sand so that pumping produces nothing but water. Besides the damage done at the well where the water first breaks in, it spreads to neighboring wells and causes their product to become partly or entirely water. The probability of such damage is usually foreseen and the method of its prevention is to insert screw pipe (or casing) in the well. It serves as the lining or wall of the well and if carried through and below the water sand and firmly landed in some sort of impervious stratum, such as clay, it prevents the water from leaking down into the well. Sometimes it is necessary to pump cement in behind the casing in order to thoroughly seal the passages down which the water might otherwise run. Several such lines (or strings) of casing are sometimes required inside the first one until they all resemble a telescope with the small end at the bottom of the well, in the oil sand.

The problem, therefore, has two separate branches: first, determining where the casing should be landed and, second, the actual work of placing it in a workmanlike manner in the well. Either one of these branches is useless without the other.

As the oil and water sands are concealed from view by their great distance below the surface of the ground, study of records of the formations encountered in previously drilled wells is the only method of determining their position in new wells. Bearing in mind the size of the territory and great number of wells, together with the fact that natural underground connection transfers the damage from one well to another and eventually injures or destroys the entire field, it will be seen that the problem of determining where new strings of casing should be landed may be fairly called a "man-sized job." It can be done only by keeping accurate record of every well and patiently working out its relation to all those surrounding it. How this has been attempted and the results obtained is the purpose of this writing.

Since February, 1913, the position of county oil well commissioner for Fresno County has been occupied by a graduate engineer who has had a number of years' experience in the oil business. Appointment to this position is made by the county supervisors. The annual cost to the county is $2,700 per year. The county derives one eighth of its revenue from the Coalinga fields. Immediately after taking the position the commisisoner introduced the following system: An office room at a central location was obtained where he has collected and filed practically all of the well logs, along with numerous detailed drawings which he has made. Besides these, he has on file reports from various companies showing the percentage of water coming from their wells. These records are open to the inspection of operators, with proper safeguards for keeping confidential such records as do not concern the public. These records were freely opened to the writer as a representative of the State Mining Bureau and some of the following facts were ascertained from them:

There are about sixty superintendents in the field. Of these an overwhelming majority have actively cooperated with the commissioner in his efforts to better conditions. In fact there has been but a single case of opposition and that from the representative of a comparatively small concern.

Attention is particularly directed to the following figures:

West Side Field. (Total, 732 wells.)

Wells reported	340	
Wells making 10 per cent to 50 per cent water	68	20% of those reported
Wells making over 50 per cent water	13	4% of those reported

East Side Field. (Total, 369 wells.)

Wells reported	113	
Wells making 10 per cent to 50 per cent water	29	25% of those reported
Wells making over 50 per cent water	4	5% of those reported

These figures show that of the 41 per cent of the wells reported to the commissioner there are 25 per cent producing over 10 per cent water. That the percentage would be higher if all the wells were reported there is little doubt.

The seriousness of the condition is well shown by the fact that the writer was informed by the president of one of the large operating companies that unless water troubles were remedied it would probably force his company to stop operations. Should such action become general the field would be irreparably injured, as an idle well making water turns all of it into the oil sands, upon which sands the life of the industry depends.

Here is one instance of how the damage works out in dollars and cents: A certain property has a well about 2,700 feet deep. It was drilled about three years ago at a cost of about $30,000. Initial production was over 200 barrels of oil per day and it has produced a total of about 100,000 barrels of oil, giving a profit of possibly $10,000. About a year ago water stopped this production almost entirely. The owners are financially unable to repair the well at present, and each day adds to the damage it is doing to surrounding property.

Fortunately, it has been actually demonstrated that there is a definite remedy for these conditions, which would otherwise mean the absolute destruction of the oil industry in California. For several years a number of men in this field have been ceaselessly working towards a means of applying the remedy. One of their results is that of having a man placed in the position of oil well commissioner, who systematically gathered and arranged evidence in a form useful to superintendents. Public opinion had to be led from the idea that nothing but a knowledge of the use of drilling tools was necessary or desirable, to the fact that *the gathering and patching together of evidence is the prime necessity,* supplemented by knowledge of practical methods. It is gratifying to those who advocated the plan in operation for the past year at Coalinga to be able to point to the following actual demonstration that it gets good results.

Three operating companies in the Coalinga field were troubled with water in a group of wells. Each one thought that his own wells were perfect and that one or both of the neighbors had wells which were flooding the entire group. The idea was so strong that it finally became a personal matter between the superintendents, who ceased to exchange information. Finally, a plan of arbitration was adopted as being the only solution. Each of the three arbitrators was a successful operator in charge of property. The commissioner's file of records was not at that time complete and the board had to make some investigations to supply such information as his office can now fully furnish.

Under the direction of this board work was done by the three companies and in four months' time the trouble was absolutely cured. It was caused principally by one well where chemical action of the water had eaten through the casing which had originally shut out the water. A single hole one half inch in diameter had flooded six wells.

The important lesson taught by the work of this board is that *their first steps in the work were:* (1) The collecting from the three superintendents all available information relating to the history of all the wells; (2) An accurate sampling of the product of each well (two or three were pumping water only and several others were making about 50 per cent water); (3) Making drawings of all the well logs showing the relative positions of all the underground formations and the various strings of casing.

Then they directed the three companies what repairs and experimenting they must perform on the wells. *They did not* themselves do any of the actual work of repairs nor even specify in detail how it should be done. Their work *was entirely advisory* and they were *backed up by a contract* which insured that their advice must be followed.

If the accomplishments of such a system as is in operation at Coalinga were limited to simply remedying the damage done by water it would pay for itself many times over, but besides this it gives promise of other benefits measured in dollars and cents. Already the work of the present commissioner has convinced some operators that some of their wells have passed through oil sands which were not recognized as such; and they will probably now go back and test these sands with the expectation of finding more oil than their first calculations indicated. It has also definitely shown that water occupies the same sands that farther up their dip have produced oil, and that as the oil is removed the water gradually creeps upward along the stratum, making it necessary to shut off this particular bed to prevent its flooding the other sands which have not yet been drained of all their oil content. This phenomenon of gradual encroachment is known as *edge water* and it must be intelligently dealt with.

Conclusions drawn by the writer from the evidence already partly outlined are as follows:

Responsibility for the serious damage by water rests upon two groups of people, namely, *superintendents* in the field, and *company officials* to whom they report. Any operator is liable to deceive himself as to the conditions of his property. It is the consensus of opinion of the operators in the field, that a superintendent who personally refuses to exchange information on underground conditions with all of his neighbors and with the county oil well commissioner, is not fitted to hold the position. Company officials who do not take the trouble to satisfy themselves that their superintendent does these things, in an open minded and fair manner have no grounds for complaint if their property is ruined, and furthermore, they are in the same position towards the community as a man would be, should he deliberately allow his house to catch fire where it would certainly burn three or four others belonging to neighbors.

Some of the problems that remain to be solved by the operators in the Coalinga field are as follows:

(1) The exact location of the beds and the composition of their contained water which destroys both steel and iron casing in from two to five years. At present it seems probable that it is the so-called "black sulphur water."

(2) The possibility of coating casing with paint or cement that will resist the chemical action. This may be difficult to accomplish, as the friction in placing the casing will tend to scrape off any coating. However, experiments should be tried, as some may succeed and none will be harmful.

(3) The possibility that some metal or alloy may be better than that used in the casing at present on the market.

(4) Means should be provided whereby the commissioner will be informed of the amount of water in all the wells in the field.

(5) A means of cooperation among all the superintendents and officials is desirable and will repay all those taking part. Such an end will be accomplished by continuing the meetings of the Coalinga Oil Men's Association, which meets for discussion of problems of interest. At each meeting a paper has been read by some man of experience.

(6) It will be necessary to provide some means whereby wells belonging to a financially embarrassed company may be repaired and also to force, preferably by arbitration, some operators to repair their wells.

A movement is under way to combine the various operators under a contract similar to that above referred to in the arbitration. By this means they can repair damage occurring on their own properties, and some of the largest operators are confident that the law affords ample relief for damage done by operators who refuse to enter into the contract.

J. R. DORRANCE
INAL PROPERT

Further investigation several months later showed the following conditions in the Coalinga field, even without complete returns from all wells (especialy those abandoned or shut down).

Percentage of water	West Side field, Number of wells	East Side field. Number of wells
0 to 5 per cent, inclusive	310	190
5 to 10 per cent, inclusive	90	67
10 to 25 per cent, inclusive	69	61
25 to 50 per cent, inclusive	44	31
50 to 75 per cent, inclusive	12	6
75 to 100 per cent, inclusive	41	16
Total in which water percentage is shown	566	371
Drilling (actual operations going on)	7	15
Drilling shut down	11	13
Shut down due to production trouble	91	------------
Shut down due to production and water troubles	41	------------
Abandoned (various causes)	61	51
Pumping	578	------------
Redrilling	17	17
Total drilled (on West Side does not include shallow territory)	788	435

Early in 1914 an arbitration association was formed, by contract, between a number of operators. They tax themselves, through a board of directors, to defray the expense of carefully determining the cause of water troubles and pointing out remedies. Each operator agrees to abide by the written decision of the board of directors when they order repairs to wells. The plan seems to be satisfactory but should be extended and made general by means of legislation.

The Kern Trading and Oil Company have been especially keen in the use of technical information, both at Coalinga and Midway, and their example has undoubtedly been a great factor in calling general attention to means of protecting the oil resources from water.

CHAPTER V.

KERN RIVER FIELD.

LOCATION.

The Kern River Field (see Plate VIII) is situated in Kern County about five miles northeast from the town of Bakersfield, being mostly in T. 28 S., R. 28 E. The Kern River flows through the southern portion of the field. A branch of the Southern Pacific Railroad was built into the field in the year 1900. This is the only oil field on the eastern side of the San Joaquin Valley.

The land immediately surrounding the field is at present not valuable except for grazing, being devoid of trees.

Topography and geology of the region have been more completely described by Mr. F. M. Anderson (Proceedings of the California Academy of Sciences, Fourth Series, Vol. III), than any other writer, and frequent quotations are here taken from his work. No attempt was made by us to study the geology of this field as such work was previously done by another public institution, presumably with the intent of publishing.

TOPOGRAPHY.

''Viewed from a distance, the topographic features of the area herein described consist of low rounded hills, which taken altogether present the aspect of a gently sloping mesa inclined toward the west. From a nearer view they are seen to be very much dissected by erosion. The larger streams coming from the Sierra meander through the zone of foothills in sinuous valleys along narrow flood-plains developed by corrasion in the yielding sediments. The intervening parts of the area are deeply cut by canyons and ravines of varying gradients, which reproduce, in measures proportionate to their size, the features of the larger streams. As the general mesa-like surface rises gradually toward the east, so too, in going upstream toward the basement formations, the canyons and their tributaries become deeper, and the hills higher and steeper. The effect is that usually produced upon yielding sandy formations by recent but rapid degradation. The topography is similar to much that is found in the more arid belt along the western border of the Great Valley.''

''The principal streams are the Kern and White rivers, Poso, Caliente and Tejon creeks, all of which derive their waters from the older areas of the Sierra, and descend thence through deep and narrow gorges, and enter the zone of foothills in rapids, below which the grade is quickly lost. With the exception of the Kern River, these streams are without water during the drier portions of the year, while in the wet seasons they are often torrential. They cross the zone of foothills in relatively wide and shallow canyons, and have developed flood-plains that are in strong contrast to the narrow defiles in the older and harder formations. The canyon of Caliente Creek offers some interesting features which will be taken up later.''

GEOLOGY.

The sediments in the field are mostly clay and sand, of Neocene age, dipping very gently (3° to 4°) to the west. Five or six miles eastward the foothills of the Sierra Nevada Mountains rise, exposing underlying granite and metamorphic rock.

THE NEOCENE SERIES.

''The Neocene deposits extend along the foothills of the Sierra from near White River southward to the Tejon Valley, forming a zone of varying width, fifty or more miles in length. This zone narrows at each end, though more gradually at the south, and has its greatest width in the section along Poso Creek.''

''As a feature of great economic value this area includes the well known oil fields of the Kern River, which are situated near the mouth of the shallow canyon of the lower Kern River. But it is not the design to give prominence to the economic features of the geology in this paper.''

STRUCTURE OF THE NEOCENE.

''The Neocene deposits of the Kern River area were evidently laid down upon a floor of older rocks that had been much eroded. This fact is illustrated by the somewhat broken boundary, by the isolated areas of granite within the Neocene, and by the filling of pre-Neocene troughs by the basal beds of the Neocene. This latter feature is particularly well shown in the case of the Caliente Canyon. To some extent the dip and strike of the basal beds conform to these irregularities, but this is not usually noticeable.''

''In the main, the structure of the Neocene beds is simple, and consists of a gentle dip to the southwest, which rarely exceeds 5° or 6°. The greatest dip is near the base in certain disturbed localities, and the flattest is along the western border of the hills. There are a few local undulations that develop low anticlinal arches elongated in a northwest and southeast direction. One of these anticlines traverses the developed oil district of the Kern River, and, according to Eldridge, another is found farther north. Another is to be seen along the eastern border of the area just north of the Kern River, and may be followed to the northwest across Poso Creek. It lies a little to the west of the Fuller's earth mine on the road from Poso station to Granite. There is a corresponding syncline to the east of this, midway between the Granite road and Adobe Canyon.''

''The evidences of faulting within the Neocene area are almost negligible, though such faulting has taken place. Faulting to a greater extent has taken place along the eastern margin of the area, following in a general way, and in part, the contact with the basement rocks, and extending also at right angles to it for a limited distance at one point at least.''

''The faulting along the margin has evidently been of the normal type, and was probably progressive, resulting in a displacement of at least a few hundred feet in some places, and much more in others. At Pyramid Hill, the lowest Neocene beds known within the area are left exposed at a considerable elevation, resting upon a floor of granite. Near Walker Basin Creek, beds of sandy ash, which are apparently of Lower Miocene age, are severed from the main area and left stranded at an elevation of 2,500 to 3,000 feet upon the granites, indicating a throw of 1,000 feet or more.''

''The structure of the Neocene beds developed by this faulting is partially expressed in the Poso anticline previously mentioned. It seems probable that the faulting has been progressive, and *pari passu* with the corrasion of such narrow defiles as that of the Kern River; but this aspect of the subject can not be fully taken up at present.''

''North of Poso Creek, erosion has greatly excavated the Neocene sediments along the line of contact, forming small deep valleys in which the strata are clearly exposed.''

''In the head of Adobe Canyon and near Granite station, where the structure of the Neocene beds resting upon or against the basement rocks is well shown, they are seen to be almost horizontal, or to dip gently westward at a low angle. In this respect they present a strong contrast to their counterparts on the opposite side of the Great Valley, where the lowest beds of the Neocene usually stand at a high angle against the basement series.''

''The average dip of the strata across the entire area in the vicinity of Poso Creek is less than 4°, and approximates 3° 30′. This is about the average along a cross-section nearly ten miles in length, and, as shown later, it fairly represents the dip in the western side of the developed oil field.''

''The entire series has in many places the appearance of stratigraphic conformity throughout, and evidence is often lacking of any great disturbance intervening between the beginning and the close of Neocene sedimentation. Both to the north and to the south of Kern River, however, there is an evident overlap of the younger portion of the series upon the older, and even upon the basement rocks to the east. Along

Caliente Creek and southward, the Neocene beds stand at a higher angle than elsewhere and beds that belong to the upper part of the series rest upon the basement rocks. Northward, near White River, there is a similar overlap. Beyond the limits of this area the evidence of overlapping is unmistakable, but within the area it took place by a process so gradual that the results are not striking.''

''There is no clear proof of an interval of erosion intervening, though the assumption of one might offer a convenient explanation for the comparatively small stratigraphic thickness as contrasted with similar beds near Sunset, Temblor and northward.''

THICKNESS AND STRATIGRAPHY.

''On account of the excellent exposures of the strata, and from the fact that deep wells have been drilled in the western part of the area, the opportunity for studying the thickness and composition of the Neocene beds is exceptionally good. Two sections have been made across the area, and two or more deep wells have given a fair representation of the stratigraphy. One of the sections crosses the area north of Poso Creek; the other extends along the Kern River; and both show some peculiarities. The aggregate thickness of the entire series, as measured in the outcrop across the strike to the north of Poso Creek, is quite 3,300 feet, and may be more, assuming the beds to have been originally horizontal.''

''Near the Kern River, where the dip varies from 2° to 8°, the measurement of its different parts separately gave an aggregate thickness of 3,250 feet; yet the apparent thickness may be somewhat deceptive because of faulting.''

''In the deep wells the thickness is naturally somewhat less, since their positions are farther from the shore line, and the section is also somewhat reduced by erosion, but these matters will be referred to later.''

''*The Outcrops.*—Within the area outlined, the sediments of the Neocene are prevailingly sandy in the outcrop, with only a moderate proportion of clay and organic shales, such as usually compose them in other parts of the coast country.''

''Toward the bottom of the series there are conglomerates, sands, and volcanic ash, making up nearly 600 feet of the lower portion. Higher up and extending above the middle of the series there are shales more or less sandy in the outcrops, or shales interstratified with sands, that make up in the aggregate a third of the series. Above the shales are sandy beds which become generally coarser toward the top, as will be shown later. It is thus possible, on the basis of lithology, to separate the combined series into three separate portions but on other grounds a twofold division has been here presented.''

"In the outcrops the clastic elements are prominent in nearly all parts of the series, and the first impression is apt to be that it is chiefly sandy. At the surface the beds are but little consolidated, as the results of erosion show. The harder beds are nearly all confined to the lower third of the series, and they are prominent only at the base and near the bottom."

"The lithological character of the individual beds is probably not always persistent over wide areas, and it is not easy, therefore, to recognize the smaller stratigraphic units in widely separated localities."

The deep well records in the southwestern part of the field, published by Mr. F. M. Anderson, show no well defined oil sands below about 1,300 feet; below that depth is a considerable thickness (2,000 feet or more) of shale resembling the Eocene of Tejon Ranch.

"As far as known the petroleum deposits of commercial value are confined to the Kern River group, and therein have a stratigraphic range of 300 to 600 feet, though unproductive beds of oil-sand are found both above and below. At any one point the productive sands rarely exceed 400 feet in thickness, and they are often confined to 250 feet or less. Mechanical difficulties often make it impracticable to draw upon all of the sands capable of yielding oil, and the perforations of the casings are sometimes extended to only half the thickness of oil strata actually encountered in drilling."

"Below the base of the Kern River group and, therefore, within the Temblor, oil-sands have been reported in the records of the deep wells, but none of them are known to be capable of yielding commercial quantities of oil. The oil is generally reported to be of lighter character than that from the oil-measures of the Kern River group. Thin streaks of oil-sand and stains of oil, and shales more or less colored by bituminous matter, if not with oil, outcrop in certain localities within the Temblor. Some of these are to be seen along Kern River east of the oil field, and in the hills north of Poso Creek as, for example, near the old fuller's earth mine. Oil-sands are reported in some old wells a quarter of a mile north of this mine, at a depth of 1,300 to 1,400 feet, and gas is still issuing from one of these wells in small quantity."

"Gas, which is generally regarded as an indication of oil, has been encountered in nearly all of the wells, old and new, that have been drilled into the Temblor beds. Considerable quantities of gas were found in both the Grace Well No. 5, and in the deep well of the Petroleum Development Company."

"Stratigraphically, the oil is not found in a single bed extending across the field, but in sandy beds more or less separated by clays and distributed through the oil-measures. The sandy beds and clays interleave, often forming an alternating series throughout the measures. As a rule, in the developed portion of the field the sands are thicker in the eastern part of the field and become thinner toward the west, and the clays are thicker on the western border and become thin and scattered toward the east. In like manner the sands are thicker toward the south, and clays increase in volume northward.''

''There is considerable lack of uniformity in the well records: but this is probably due more to faulty records than to irregularities in the beds themselves. Both sands and clay beds are believed by some to be lenticular in section, and this is sometimes given as the cause of troubles met with in controlling the underground water. But if a lenticular condition has really been observed in any case, it is likely to have been found along certain directions, and belongs primarily to the sands rather than to the clays, since it would owe its origin to the sorting action of currents during deposition. However, the idea of this condition comes solely from a study of the well records, and the faulty data furnished by some of these should not be forgotten. If a well record fails to record a particular bed of clay, it does not prove its absence, but possibly only a failure to detect it.''

''The structure of the beds is almost that of a simple monocline, but when studied in detail the beds undulate somewhat, forming slight anticlines and synclines striking northwest to southeast.''

''The ultimate areal extent of the field has not been proved by actual developments, though the limits may be definitely known toward the northeast, if not also toward the southwest.''

''Thus far water has proved to be more troublesome on the southwestern border of the field; and this is partly on account of the thinner clay beds in this direction, and the greater difficulty met with in shutting it out from the wells, or in confining it to certain limits by means of these clays.''

''The gravity of the oil varies from 10.4° Baumé to 17.0° Baumé, though a large percentage of the production is between 14.5° and 16° Baumé. Still lighter oil comes from strata below the oil measures of the Kern River group.''

''Watersands, which are the source of much trouble, are found both above and below the productive beds—some within the oilmeasures, though in some cases water has been let into the oilmeasures by accident or by faulty drilling. It is usually possible to shut out the upper water, and when the horizon of the lower watersands is once learned, drilling may be stopped above it. There are usually sufficient clays suitably situated for the control of the underground water if the conditions are correctly known beforehand.''

''The question as to the origin of petroleum is one much debated; but in California there is overwhelming evidence in favor of an organic origin, and the facts point to certain low organisms of both marine and fresh water habitat. In the Tertiary formations of California, *Dia-*

tomaceæ are extremely abundant, and beds that are largely composed of their remains abound in all parts of the Neocene series, excepting possibly the latest. In the Mount Diablo range diatomaceous and other organic shales often make up a large percentage aggregate of the Monterey and later groups, and they occur also in the Etchegoin group, included by Ralph Arnold in the so-called 'McKittrick series.' "

"The opinion has been unequivocally expressed that in the Coalinga field the real source of the petroleum is in the Eocene shales underlying the Neocene, and that migration of the petroleum upward through the strata has brought it into its present repositories in the Neocene oil-measures. That petroleum, in some parts of the Mount Diablo range and elsewhere, has originated in the Eocene can not be denied, and it is also now found there in many places. But to conclude that all or any of the Neocene oil-measures have derived their supplies from the Eocene is illogical and unnecessary. The Neocene beds themselves contain the same organisms in even greater abundance than does the Eocene, and this is particularly true in the Mount Diablo range. And there is no reason to suppose that the oil found in the Neocene measures has not originated in the Neocene strata themselves."

"Naturally in the sedimentation of any basin the sandy detritus usually remains near shore, and the finer materials are carried away to other localities to be deposited. Also if *Diatomaceæ* and other delicate organisms form any appreciable deposits they will more probably be formed off shore. In subsequent regional deformations of the strata, the organic deposits are apt to be left occupying the position of synclinal depressions, bounded by the sandy shore line deposits left lying in positions inclined toward the interior of the basin. If such organic deposits give rise to any supply of petroleum or other liquid or gaseous substances, these may be forced to migrate laterally along the bedding-planes of the strata, and into the sandy strata of the border, far more readily than they could be forced upward through the clays and shales and into overlying beds."

"And, if deposits of petroleum are subsequently found in sandy shore deposits, we may expect to find not far away in the same beds the source and origin of it. Along the Kern River the conditions are all that could be required to support the view that lateral migration has been the means by which accumulation has taken place, and the same may be said of all the other producing or non-producing fields in the Temblor basin. The extent to which water, oil, and gas may migrate laterally along bedding-planes in the progress of geologic periods is, of course, very great; but the fact that it is retained at all in the rocks, even under enormous pressure, is very good proof that it can not migrate in a vertical direction, transverse to the bedding-planes."

HISTORY OF DEVELOPMENT.

Many years before any drilling was done seepages of oil and gas were known to exist along the Kern River, in Sections 2 and 3, T. 29 S., R. 28 E. One of the earliest writers on the subject was W. A. Goodyear, who visited and described the place in 1887 (Seventh Annual Report, State Mineralogist, p. 67). Early developments were described by W. L. Watts in 1900 (Bulletin 19, California State Mining Bureau, pp. 110 to 116). The first drilled well was the Elwood, Section 3, T. 29 S., R. 28 E., in June, 1899, which produced 20 barrels per day from a depth of 320 feet, by September, 1900, there were 134 completed wells in the field. It is particularly worthy of note that all the subsequent development work has only slightly enlarged the area that might have been considered proved fourteen years ago.

Our map indicates the abandoned wells surrounding the proved area; most of these never encountered oil in paying quantities.

Several wells, from two to six miles to the west and northwest of the proved field, have been drilled by the Standard Oil Company with but slight success, although in every case some oil has been encountered. Summary of results is as follows:

No. 1. Sec. 5 (NW. ¼ of SE. ¼) T. 28 S., R. 27 E. Depth 2,940 feet, tar sand 2,645 feet to 2,650 feet, show of oil and gas in shale 2,795 feet, little oil in sand 2,865 feet to 2,875 feet, best showing of oil sand 2,900 feet to 2,910 feet.

No. 1. Sec. 15 (NW. ¼ of SE. ¼) T. 28 S., R. 27 E. Depth 2,835 feet, first oil sand at 2,064 feet and about twenty other oil sands reported 5 feet to 15 feet in thickness.

No. 1. Sec. 21 (SE. ¼ of NW. ¼) T. 28 S., R. 27 E. Depth 3,195 feet, slight showing at 2,550 feet and 2,690 feet.

No. 1. Sec. 27 (SW. ¼ of NE. ¼) T. 28 S., R. 27 E. Depth 2,499 feet, tar sand 2,200 feet to 2,210 feet, and 2,243 feet to 2,246 feet, sands showing oil 2,440 feet to 2,448 feet, and 2,460 feet to 2,497 feet.

No. 2 "State." Sec. 35 (NE. ¼ of NE. ¼) T. 28 S., R. 27 E. Depth 3,650 feet, heavy oil sand 1,810 feet to 1,850 feet, numerous other showings of oil, brown shale from 2,800 feet down with showings of gas. This is similar to results at the Grace well, Sec. 8, T. 29 S., R. 28 E.

Towards the west the oil sands apparently are filled with water and the northern and southern extensions of the field may have been unsuccessful because the sand beds were not relatively so plentiful. Eastward extension of the field is limited by the outcrop of the oil sands.

Water has been a very serious obstacle in producing operations of the Kern River field, although all the available evidence tends to show that ordinary care, based on engineering skill and knowledge of geology, could have easily prevented the needless expense to which operators have been put in handling the water after it was allowed to enter the wells. An oft repeated statement that large companies are always the most efficient operators is in this case refuted, as about 40 per cent of the proved land has been operated by a single concern.

The history of development of the Kern River Field since 1903, and the rate of production, is clearly shown on the accompanying diagram

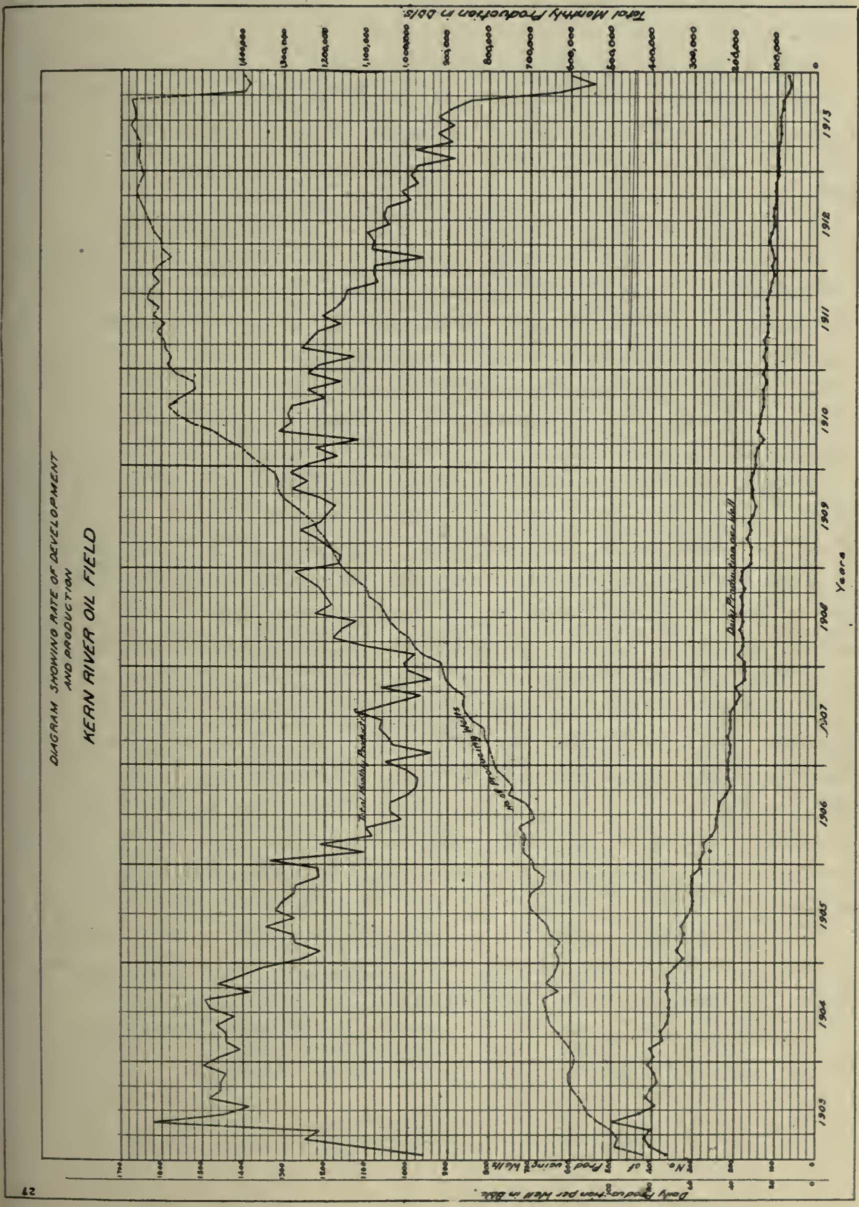


Fig. 27.

(page 203) drawn largely from figures supplied by the Standard Oil Company. Unfortunately detailed figures for the first two or three years are not available.

1903 to 1906.—During this period there was a gradual increase in the number of producing wells at the rather uniform rate of 57 per year (560 to 790) which was insufficient to maintain the total production which fell from about 1,500,000 barrels per month to about 1,000,000 barrels.

1907 to 1910.—Coincident with the increase in price of oil the rate of drilling producing wells increased to about 195 per year. This increased rate of drilling quickly raised the monthly production to about 1,200,000 barrels per month and was sufficient to maintain it at that level.

1911 to 1913.—This period has been one of very little drilling activity as the proved area has been nearly drilled to its capacity. The monthly production has consequently fallen to about 600,000 barrels per month. In the latter part of the year 1913 some 300 completed wells ceased pumping, probably on account of the fact that pumping a 17-barrel well is not profitable at the present price of oil.

The rate of decline in production, as shown by the diagram, is very remarkable for its regularity. From 1903 until the end of 1906 the production per well per day fell from about 90 to 40, or at the rate of 12 barrels per year. From the beginning of 1907 until the end of 1913 the production per well per day fell from 40 to 17 or a decrease of 3.8 barrels per year. It is worthy of particular notice that the rate in decline was checked in 1907 by the increase in rate of drilling and it is equally worthy of notice that the rate of decline was not altered by the lessened drilling activity about 1911.

The future of the field may be rather accurately foretold from the diagram (see also Coalinga page 125). The price of oil is the governing factor. It costs from $3 to $5 per day to pump a well. The average well during 1913 produced 17 barrels and each year will probably see this figure decreased by about 3 barrels, hence the next few years will doubtless see many producing wells suspended, for a part of the time at least. The figures for 1914 point to the same conclusion.

The field contains about ten square miles of proved land with 1,675 producing wells, or an average of 3.9 acres per well. The total production to date is about 167,357,573 barrels, or 25,900 barrels per acre of proved land. Future work will apparently increase these figures by only a small percentage unless entirely new territory is discovered.

MONTHLY PRODUCTION AND STATISTICS OF FIELD DEVELOPMENT.

(Standard Oil Company.)

Kern River Field.

Year	Wells producing	Number of wells completed during month	Monthly production (barrels)	Barrels per well per day
1903.				
January	422		961,000	73
February	492		1,120,000	81
March	484		1,252,400	84
April	500		1,215,000	81
May	533	18	1,618,806	98
June	558	9	1,447,750	86
July	568	13	1,386,865	79
August	579	17	1,485,768	83
September	595	8	1,455,210	81
October	606	19	1,455,295	78
November	606	9	1,444,710	79
December	593	9	1,499,295	82
Totals		102	16,342,099	
1904.				
January	591	11	1,461,820	80
February	601	7	1,408,940	81
March	617	9	1,442,425	75
April	631	16	1,441,475	76
May	650	14	1,469,901	73
June	657	12	1,421,010	72
July	661	8	1,481,978	72
August	669	3	1,496,871	72
September	630	10	1,383,480	73
October	660	3	1,466,142	72
November	641	4	1,401,543	73
December	633	9	1,350,655	69
Totals		106	17,226,240	
1905.				
January	630	5	1,259,390	65
February	640		1,212,686	68
March	626		1,274,918	66
April	651	11	1,277,240	65
May	657	13	1,347,714	66
June	675	10	1,274,830	63
July	698	19	1,322,326	61
August	701	6	1,303,455	60
September	696	9	1,276,930	61
October	670	5	1,271,687	61
November	666	5	1,214,973	61
December	690	3	1,217,696	57
Totals		86	15,253,845	
1906.				
January	694	3	1,235,869	57
February	715	1	1,105,163	55
March	715		1,211,170	55
April	712	5	1,084,750	51
May	727	6	1,100,255	49
June	689	5	1,013,930	49
July	696	5	1,041,558	48
August	712	4	1,041,735	47
September	751	3	993,490	44
October	742	5	977,460	42
November	759	5	975,300	43
December	781	8	1,044,486	43
Totals		50	12,825,166	

Kern River Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production (barrels)	Barrels per well per day
1907.				
January	790	5	1,054,340	43
February	796	1	941,720	42
March	801	7	1,035,147	42
April	811	14	1,046,560	43
May	811	14	1,068,184	42
June	841	17	1,061,908	42
July	858	8	1,119,145	42
August	866	7	1,047,050	39
September	860	16	937,230	37
October	888	19	1,066,890	39
November	907	23	940,560	35
December	912	17	997,280	35
Totals	----------	148	12,346,014	
1908.				
January	918	20	1,009,424	35
February	961	15	980,767	38
March	983	7	1,103,770	36
April	996	17	1,080,108	36
May	1,022	15	1,161,595	37
June	1,042	14	1,124,178	36
July	1,056	9	1,225,545	37
August	1,066	23	1,193,720	36
September	1,093	16	1,198,020	37
October	1,099	22	1,211,274	35
November	1,123	18	1,240,750	37
December	1,148	18	1,274,428	36
Totals	----------	194	13,803,579	
1909.				
January	1,166	16	1,164,487	32
February	1,176	14	1,061,225	32
March	1,186	11	1,192,060	32
April	1,199	21	1,220,350	34
May	1,215	18	1,261,363	32
June	1,228	20	1,212,600	33
July	1,252	16	1,195,060	31
August	1,277	19	1,174,002	30
September	1,304	16	1,216,060	31
October	1,314	12	1,280,395	31
November	1,314	15	1,245,150	32
December	1,324	17	1,285,490	31
Totals	----------	195	14,508,242	
1910.				
January	1,356	26	1,243,902	30
February	1,383	20	1,169,640	30
March	1,404	28	1,224,655	29
April	1,447	32	1,119,450	26
May	1,476	46	1,311,765	29
June	1,529	42	1,284,750	28
July	1,567	22	1,290,685	27
August	1,582	21	1,281,695	26
September	1,556	15	1,200,450	26
October	1,519	21	1,243,583	26
November	1,521	15	1,161,210	25
December	1,566	13	1,244,650	26
Totals	----------	301	14,776,435	

Kern River Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production (barrels)	Barrels per well per day
1911.				
January	1,586	17	1,217,835	25
February	1,578	13	1,132,180	26
March	1,590	12	1,257,980	25
April	1,591	21	1,239,900	26
May	1,611	15	1,220,470	24
June	1,592	8	1,164,150	24
July	1,620	11	1,208,070	24
August	1,606	12	1,172,575	24
September	1,636	6	1,164,900	24
October	1,628	7	1,147,155	23
November	1,604	9	1,071,000	22
December	1,622	5	1,082,675	21
Totals		136	14,078,890	
1912.				
January	1,609	7	1,080,350	22
February	1,576	13	961,495	21
March	1,600	6	1,088,875	22
April	1,600	11	1,081,650	23
May	1,617	8	1,098,020	22
June	1,627	7	1,047,300	21
July	1,637	9	1,058,805	21
August	1,644	11	1,051,365	21
September	1,655	4	992,640	20
October	1,660	6	1,016,645	20
November	1,654	4	975,750	20
December	1,643	4	993,550	19
Totals		90	12,446,445	
1913.				
January	1,649	7	978,670	19
February	1,656	4	884,520	19
March	1,652	2	980,530	19
April	1,651	3	890,400	18
May	1,663		926,435	18
June	1,675	4	885,150	18
July	1,662		926,590	18
August	1,666	7	891,870	17
September	1,673	3	845,700	17
October	1,396	3	627,750	14
November	1,382		542,700	13
December	1,397		600,625	14
Totals		33	9,980,940	
Total completed		1,441		
Idle or abandoned		466		
1914.				
January	1,397		600,625	14
February	1,400		560,420	14
March	1,399	1	619,380	14
April	1,382	3	591,450	14
May	1,421	1	616,125	14
June	1,431	3	610,500	14
July	1,432	4	623,100	14
August	1,459		623,565	14
September	1,449	1	577,500	13
October	1,390		564,045	13
November				
December				
Totals				

FINANCIAL RESULTS.

Financial results in the Kern River Field during the year 1913, as shown by 50 companies, producing 4,208,231 barrels of oil from 932 wells, are summarized as follows:

Capital. This figure can not be definitely determined, particularly the second item (property value) and any error here is apt to be on the side of an overestimate.

Cash paid for stock	$5,198,416 00
Property paid for stock	3,520,029 00
Total	$8,718,445 00

Dividends are difficult to determine as many concerns are close corporations, making no public reports, hence our figures may be slightly below the actual amounts. Records earlier than 1909 were not available:

1909—22 companies	$1,123,129 00
1910—24 companies	392,472 00
1911—22 companies	389,822 00
1912—26 companies	454,095 00
1913—19 companies	361,444 00
	$2,720,962 00

Nine companies paid dividends continuously from 1909 to 1913, four simply receiving royalty oil. The dividend companies produced 1,804,454 barrels of oil, or 18 per cent of the field total, their average price being 32.7 cents. Daily production per well averaged 17 barrels, and for the dividend companies 26.4 barrels. For further figures see table on page 10.

The general condition of the Kern River Field in 1912 is shown by the following figures derived from the operations of 67 companies, producing 7,553,165 barrels, or 60 per cent of the total production of the field.

Thirty-five different companies are represented in a complete list of dividend payers.

Fifteen companies paid dividends during each of four years (1909 to 1912).

Five companies paid dividends during each of three years.

Seven companies paid dividends during two years.

Eight companies paid dividends one year.

The production during 1912 by 25 dividend paying companies was 3,364,151 barrels from 461 wells and 47 cents per barrel was received for the oil. Of this production 2,310,119 barrels were produced by the fifteen companies continuously paying dividends for four years, and the average price per barrel received by them was 39 cents.

Cash to the amount of $2,702,385 was received for the total production of oil, considered in this summary, or an average price of 33 cents per barrel.

Total operating expense (not including depreciation, taxes, insurance and interest, which are here referred to as fixed charges) was $1,585,680, averaging $3.83 daily per well, or 21 cents per barrel. The daily operating expense per well of 28 dividend paying companies with 526 wells was $4.40 and furthermore was $4.32 for the companies that paid dividends during all four years from 286 wells.

Daily production per well, from the figures under consideration, show the average for the field to have been 18 barrels, and for the companies which paid dividends 22 barrels.

DIRECTORY OF COMPANIES OPERATING IN KERN RIVER FIELD.

Company	Location	Wells completed	Gravity	Official address
*Acme Development Co.	29-28-28	8	12.5	800 J st., Sacramento.
Alma	4-29-28	12	14.3	306 Mills Bldg., San Francisco.
Alma, Jr.	4-29-28	11	--------	306 Mills Bldg., San Francisco.
*American Crude	29-29-28	9	13.6	Bakersfield.
Apollo	4-29-28	19	14.2	1031 Mills Bldg., San Francisco.
Amourot	5-29-28	6	--------	1031 Mills Bldg., San Francisco.
Associated Oil Co.—				
Canfield Div.	29-28-28	57	--------	Sharon Bldg., San Francisco.
Canfield Div.	28-28-28			
Central Point Div.	4-29-28	51		
Green & Whittier Div.	30-28-28	57		
Green & Whittier Div.	31-28-28			
San Joaquin Div.	4-29-28	223		
San Joaquin Div.	29-28-28			
San Joaquin Div.	32-28-28			
San Joaquin Div.	5-29-28			
San Joaquin Div.	30-28-28			
Bald Eagle	30-28-28	13	13.8	110 Sutter st., San Francisco.
Bankers	28-28-28	33	13.6	805 Security Bldg., Los Angeles.
Betts, Geo.	29-28-27	8		
*Black Jack	4-29-28	7	--------	Box 24, Bakersfield.
Broadway	8-29-28	2	--------	1102 Broadway, Oakland.
*Boston Petroleum	20-29-28	16	13.3	131 State st., Boston, Mass.
*Calloma Oil Co.	31-28-28	7	13.6	1913 Chester ave., Bakersfield.
*Calloma Extension	31-28-28	5	13.3	Bakersfield.
Cleveland	8-28-28	1		
*Clampitt, E. A.	4-29-28	12	14.6	
Claremont	32-28-28	13	14.9	Union Oil Bldg., Los Angeles.
*Del Rey	5-29-28	16	13.1	2 Union Savings Bank Bldg., Pasadena.
*Eastern Consolidated	29-28-28	6	13.7	717 International Bank Bldg., Los Angeles.
*East Puente	4-29-28	8	13.5	635 Fifth st., San Diego.
*El Dorado	29-28-28	5	13.6	Box 24, Bakersfield.
Enos	6-29-28	18	13.8	226 Crocker Bldg., San Francisco.
Four Oil Co.	4-29-28	12	14.4	1031 Mills Bldg., San Francisco.
Berry, F. C.	29-29-28	5		
*Fox & Garrett	25-28-27	8	13.0	Bakersfield.
*General Belgium of Cal., Ltd.	36-28-27	4	12.8	
Grey Oil Co.	2-28-27	39		
Grey Oil Co.	3-28-27			
*Homer	8-29-28	4	13.0	
*Illinois Crude	32-28-28	9	14.6	Box 441, Bakersfield.
Jewell	25-28-27	9	12.6	Theatre Bldg., San Jose.
*Junction	9-29-28	8	13.0	Russ Bldg., San Francisco.
Beir, J. C.	8-29-28	3		
Kern Union	3-29-28	5	--------	Union Trust Bldg., Los Angeles.
*Kern Four	4-29-28	28	13.9	712 Security Bldg., Los Angeles.
*Knob Hill	4-29-28	33	14.9	1241 I st., Fresno.
Kern River Oil Co.	4-29-28	13	13.9	238 Merchants Ex. Bldg., San Francisco.
Kern River Oil Fields Co., Ltd.	33-28-28	--------	--------	350 Mills Bldg., San Francisco.
Kern River Oil Fields Co., Ltd.	32-28-28	240	14.8	
Kern River Oil Fields Co., Ltd.	19-28-28	15		
Kern Trading and Oil Co.	3-29-28	229		
Linda Vista	29-28-28	9	--------	1102 Broadway, Oakland.
Liscomb & Bridge	30-28-28	8	14.6	1667 Chester ave., Bakersfield.
Los Angeles-Kern	25-28-27	6	12.9	612 H. W. Hellman Bldg., Los Angeles.
Merchants and Bankers	36-28-27	4		
Midway Drillers	8-29-28	2		
*May Oil Co.	9-29-28	6	12.8	408 Consolidated Realty Bldg., Los Angeles.
*Mecca Oil Co.	29-28-28	14	13.9	Box 293, Bakersfield.
Mecca No. 2	19-28-28	6	13.0	
*Melwood	21-28-28	4	12.9	

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*Member Independent Oil Producers' Agency.

Companies Operating in Kern River Field—Continued.

Company	Location	Wells completed	Gravity	Official address
Monte Cristo	5-29-28	59	--------	323 Balboa Bldg., San Francisco.
*Nevada County	30-29-28	19	14.3	Nevada City.
Ohio Crude	20-28-28	8	--------	346 Pacific Electric Bldg., Los Angeles.
*Ojai Valley	21-28-28	16	13.2	604 Delta Bldg., Los Angeles.
Pacific Crude	30-28-28	9	--------	112 Market st., San Francisco.
*Parker, M. C.	29-29-28	12	13.5	
Peerless	31-28-28	58	14.6	824 Crocker Bldg., San Francisco.
Petroleum Dev.	2-28-29	108	--------	401 Kerckhoff Bldg., Los Angeles.
	3-28-29			
	4-28-29			
	9-28-29			
	10-28-29			
	15-28-29			
	18-28-29			
*Potomac	29-28-28	10	13.8	717 International Bank Bldg., Los Angeles.
*Patrica	29-28-28	14	13.6	Box 441, Bakersfield.
*Pricewell	29-28-28	8	13.5	Union League Bldg., Los Angeles.
Piedmont	31-28-28	8	--------	1102 Broadway, Oakland.
*Rambler	19-28-28	15	13.0	Union Oil Bldg., Los Angeles.
*Revenue	4-29-28	12	13.4	404 Chamber of Commerce Bldg., Pasadena.
Sacramento	29-29-28	13	14.0	800 J st., Sacramento.
Section Five	9-29-28	8	--------	216 Pine st., San Francisco.
*Section Six	--------	--------	13.8	
Sovereign	31-29-28	10	14.1	48 Geary st., San Francisco.
Sterling	31-29-28	41	14.1	Kohl Bldg., San Francisco.
Sesnon	29-28-28	14	--------	928 Monadnock Bldg., San Francisco.
Standard Oil Co.	5-28-29	--------	--------	Standard Oil Bldg., San Francisco.
Standard Oil Co.	15-28-29			
Standard Oil Co.	21-28-29			
Standard Oil Co.	27-28-29			
Standard Oil Co.	35-28-29			
*St. Clair and Jastro	6-28-29	8	13.0	Bakersfield.
*Sesame	21-28-29	--------	--------	1046 Golden Gate ave., San Francisco.
Stauffer	28-28-28	8	--------	624 California st., San Francisco.
*Tejon	36-28-27	11	13.0	Bakersfield.
*Traders	19-28-28	15		
*Traffic Sec. 19	19-28-28	6	13.0	Union Oil Bldg., Los Angeles.
Traffic Sec. 30	30-28-28	10	13.9	616 Union Oil Bldg., Los Angeles.
Traffic Sec. 36	36-28-28	2	12.7	
Thomas & Potter	8-29-28	2	--------	Bakersfield.
*Vesta	31-29-28	13	14.0	Bakersfield.
Volcan Oil and Refining	8-29-28	6	--------	First and I sts., San Diego.
*Wrenn	30-29-28	8	14.1	616 Union Oil Bldg., Los Angeles.
West Shore	32-29-28	25		
*Yellowstone	20-29-28	5	13.2	604 Title Insurance Bldg., Los Angeles.
Total	--------	1,907		

*Member Independent Oil Producers' Agency.

The amount of oil produced by various companies in 1913 is indicated by the figures on pages 38 and 41.

DRILLING.

Drilling conditions and costs in the Kern River Field are indicated by the following figures for 154 wells:

Depth—Average 950 feet (max. 1,223 feet, min., 725 feet).
Rate of drilling—Average, 14.1 feet per day.

	Per well	Per foot
Cost of labor	$1,803 00	$1 90
Cost of material	4,750 00	5 00
Total cost	$6,553 00	$6 90

Wells are drilled with light Standard tools; two and sometimes three strings of casings are used.

PUMPING.

Production or pumping is more difficult than the shallow depths might indicate, owing to the low gravity of the oil (12° to 16° Baumé) and the great amount of water that is handled. In some portions of the field air compressors are used to raise the oil and water together.

The following account is for a large property (338 wells) and is possibly above the average for the field:

Pumping	$36 01	per well per month
Repairing wells	48 74	per well per month
Collecting and cleaning oil	10 41	per well per month*
General maintenance	1 55	per well per month*
Superintendence	12 60	per well per month*
Miscellaneous	9 02	per well per month
Fuel	25 00	per well per month
	$143 33	per well per month
	4 78	per well per day

As the average production per well per day during 1913 was 17 barrels, the average cost of production is probably from 20 cents to 28 cents per barrel. In connection with this latter figure it must be emphasized that the accounts do not include an item for the return of capital invested, nor other fixed charges.

The great economy in pumping with jacks and powers, where it is possible, is shown by the following monthly account (averaged from four months) covering 229 shallow wells, pumping 14° Baumé oil.

Equipment Cost.

Steam power station, nine powers complete, with motors, transformers and electric lines	$100,264 44
Steam lines	17,858 84
Gas lines	3,582 83
Total equipment	$121,706 11
Per well	531 47

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*With these items omitted total per day is $3.96 for simply pumping.

Operation Cost.

Pumpers at wells	$275 19	
Firemen, oilers, etc.	862 48	
Fuel oil	409 12	
Electricity	941 35	
Material at power plants	118 54	
Material at wells	26 09	
Total operating cost	$2,632 77	
Operating cost per well day		$0 383

Repair Cost.

Labor at power plants	$541 87	
Material at power plants	318 77	
Labor at wells	1,010 85	
Material at wells	574 34	
Total repair cost	$2,445 83	
Repair cost per well day		0 356
Operating and repair cost per well day		$0 739

COMPRESSED AIR.

The expense of handling water by compressed air, which has been allowed to flood a field, is shown by the following figures of the Peerless Oil Company in the Kern River Field (A. G. Crites, California Oil World, February 6, 1913). There are about 60 wells on the property, 1,100 feet deep, and twenty of them are so flooded with water from above, below and between the oil sands, that air lifts are used to lower the water level. Ordinary pumps lift the oil which comes into the wells when the water is lowered. Of course considerable oil arises with the water and is collected in the sumps, and some water is mixed with the pumped oil.

The air is used at a pressure of about 150 pounds, being carried down the well by 1¼ inch pipe and entering at the bottom of 3 inch discharge pipe. Air is piped about the property in 7⅝ inch lines which to a certain extent serve as reservoirs.

There are several compressor plants, some using gas engines and some steam, so a direct distribution of cost per well is impossible from the figures at hand.

Gas plants compress	2,600 cu. ft. per min.
Steam plants compress	1,850 cu. ft. per min.
Total	4,450 cu. ft. per min.

Water lifted, 15,800 barrels per day. (Approximately 800 barrels per well.)

Assuming that the gas plants serve twelve wells, as indicated by its proportion of air, the following account can be distributed:

Cost of Equipment (gas engines, compressors and piping complete).

320 horsepower	$39,344 19	(March 4, 1910)
420 horsepower	22,781 79	(Jan'y 2, 1912)
	$62,125 98	

Depreciation at 10 per cent reduces total to $55,240.75 on January 2, 1912 (and possibly that figure might have been approached had the plant been installed as a single unit to begin with).

Cost of Operation of Gas Engines and Compressors during 1912.

Interest at 6 per cent on $55,240.75	$3,314 44
Depreciation at 10 per cent	5,524 97
Labor, one half time of engineer at $200 per month	1,200 00
Labor, 2 engineers at $135 per month	3,240 00
Repairs and extra labor	862 40
Oil, waste and incidentals	948 48
Total year	$15,090 29
Per well day	3 44

Assuming the daily production were even as high as 25 barrels per well, the above figures would show a cost per barrel of oil of 13.8 cents, largely on account of water trouble. As the average dividend per barrel (produced by the dividend companies) in 1913 was 19.9 cents, it appears that dividends might easily have been 50 per cent greater if there were no water troubles.

The action of air lifts has been described by several writers (E. M. Ivens, Journal of American Society, Mechanical Engineers, 1909; Edward A. Rix, Oil Industry, June 15, 1910; Herbert T. Abrams, School of Mines Quarterly, April, 1912, Columbia University; Arnold and Garfias, Technical Paper 70, U. S. Bureau of Mines) and will not be discussed here, but the following tables by Mr. Geo. H. Reichard and Edward A. Rix, are believed to be worth reprinting.

Approximate Cubic Feet of Free Air and Working Pressure Required to Raise One Gallon of Water by Air Lift.

$$\text{FORMULA} = \frac{L}{\text{Log.}\,\frac{H + 34}{34} \times 234}$$

H = Submergence in feet

L = Lift in feet

RATIO OF SUBMERGENCE TO LIFT.

Lift in feet	25 per cent, ⅓ to 1		33 per cent, ½ to 1		43 per cent, ¾ to 1		50 per cent 1 to 1		55 per cent 1¼ to 1		60 per cent 1½ to 1		66 per cent 2 to 1		70 per cent 2½ to 1		75 per cent 3 to 1	
	Free air, cubic feet	Working pressure	Free air, cubic feet	Working pressure	Free air, cubic feet	Working pressure	Free air, cubic feet	Working pressure	Free air, cubic feet	Working pressure	Free air, cubic feet	Working pressure	Free air, cubic feet	Working pressure	Free air, cubic feet	Working pressure	Free air, cubic feet	Working pressure
20	--------	--------	--------	--------	--------	--------	.428	9	.365	11	.310	13½	.252	18	.217	22½	.195	27
30	--------	--------	--------	--------	--------	--------	.470	13½	.400	17	.350	20	.290	27	.255	34	.230	40½
40	--------	--------	--------	--------	--------	--------	.508	18	.435	22½	.387	27	.325	36	.287	45	.263	54
50	--------	--------	--------	--------	--------	--------	.546	22½	.470	28	.422	34	.360	45	.320	56	.285	67½
60	--------	--------	--------	--------	--------	--------	.582	27	.510	34	.457	40½	.392	54	.350	67½	.323	81
80	--------	--------	--------	--------	--------	--------	.653	36	.575	45	.522	54	.455	72	.410	90	.380	108
100	--------	--------	--------	--------	.850	34	.720	45	.640	56	.585	67½	.512	90	.465	112½	.433	135
120	--------	--------	--------	--------	.915	40½	.785	54	.703	67½	.642	81	.567	108	.520	135	.483	162
140	--------	--------	--------	--------	.982	47	.847	63	.763	79	.697	94½	.622	126	.572	157½	.533	189
160	--------	--------	--------	--------	1.047	54	.907	72	.820	90	.755	108	.675	144	.624	180	.583	216
180	--------	--------	--------	--------	1.107	61	.965	81	.875	101	.810	121½	.725	162	.672	202	.630	243
200	1.8	30	1.436	45	1.167	67½	1.022	90	.930	112½	.862	135	.775	180	.720	225	.675	270
250	1.96	38	1.592	56	1.312	84	1.156	112½	1.069	141	.988	168	.895	225	.830	282		
300	2.12	45	1.750	67½	1.507	100	1.292	135	1.206	169	1.110	200	1.010	270	.942	338		
350	2.28	53	1.897	79	1.635	118	1.449	157½	1.317	197	1.232	236	1.110	315	1.050	394		
400	2.45	60	2.045	90	1.725	135	1.542	180	1.429	225	1.345	270	1.232	360	1.155	450		
450	2.60	68	2.182	100	1.850	152	1.669	205	1.542	253	1.457	304	1.337	410	1.280	506		
500	2.74	75	2.328	112½	1.952	169	1.790	225	1.657	281	1.570	338	1.442	450	1.356	562		
550	2.88	83	2.455	128	2.105	185½	1.907	247½	1.772	309	1.678	271	1.564	495				
600	3.02	90	2.564	135	2.225	205	2.018	270	1.884	337½	1.784	410	1.642	540				
650	3.16	98	2.730	146	2.345	219	2.175	292½	2.012	365½	1.908	438	1.742	585				
700	3.31	105	2.845	157½	2.460	236	2.258	315	2.100	394	2.000	472	1.842	630				
750	3.45	113	2.970	169	2.576	256	2.353	337½	2.225	424	2.080	512	1.935	675				
800	3.60	120	3.095	180	2.690	270	2.465	360	2.320	450	2.190	540	2.063	720				
850	3.72	128	3.215	191	2.800	287	2.570	382½	2.410	478	2.29	574	2.125	765				
900	3.85	135	3.338	202½	2.915	304	2.675	405	2.50	506	2.325	608	2.220	810				
950	3.98	143	3.455	214	3.0	322	2.780	427½	2.610	535	2.485	644	2.310	854				
1,000	4.11	150	3.575	225	3.465	337½	2.885	450	2.710	562½	2.580	675	2.407	900				

Brake Horsepower to Compress 10 Cubic Feet Free Air Per Minute.

Gauge pressure	Brake horsepower	Gauge pressure	Brake horsepower	
5	.235	130	2.14	TWO STAGE
10	.435	140	2.23	
15	.606	150	2.31	
20	.756	200	2.60	
25	.9	250	2.85	
30	1.02	300	3.07	
40	1.25	350	3.26	
50	1.45	400	3.40	
60	1.60	450	3.54	
70	1.77	500	3.68	
80	1.92	600	4.00	
90	2.05	700	3.85	THREE STAGE
100	2.18	800	4.00	
110	1.98	900	4.16	
120	2.07	1,000	4.32	

CHAPTER VI.

MIDWAY-SUNSET DISTRICT.

Location.

The Midway District (see Plates IX and X) takes in a strip of territory about six miles wide and fourteen miles long, with a northwest and southeast trend. It lies northeast of the Temblor range and north of the south line of T. 32 S, Rs. 23 and 24 E.

The Sunset District is a continuation of the Midway District three miles to the southeast. In the following discussion the two districts will be treated together as the Midway-Sunset District. Common usage divides the two fields along the southern boundary of T. 32 S., Mount Diablo base and meridian.

The climate is hot and dry in the summer. The winter is mild with a moderate amount of rain in downpours. The rapid precipitation tears down the soft sediments and cuts deep gullies. The vegetation consists of brushes similar to sagebrush and a few cottonwood trees. The winter rains bring up a goodly crop of grasses which makes sheep raising possible. The underground water supply is saline. Potable water is brought in to the region by cars from the Kern River Valley, and by pipe lines from other neighboring regions.

HISTORY OF THE DEVELOPMENT OF THE MIDWAY-SUNSET DISTRICT.

The first systematic development work in the Midway-Sunset District was done about 1894 and on the southwest border of the Sunset Field, in the region about Hazelton on Secs. 12 and 13, T. 11 N., R. 24 W., and Sec. 18, T. 11 N., R. 23 W. The wells were all near the outcrop and in shallow territory. The depths of the wells varied from 80 feet to 1,350 feet. The gravity of the oil varied from 12° Baumé to 16° Baumé. The wells averaged one to five barrels of oil per day, which was refined by Jewett & Blodget in the district. Considerable asphaltum was refined from superficial deposits in and above the Monterey shale. In August, 1900, there were eighteen producing wells in the district. Development advanced northwestward along the northeast flank of the Temblor range, following close to the outcrop of the oil sand. The deeper territory in the Midway Field has been proved since 1908. Previously it was not realized that a second oil sand lay below the outcropping oil sand, which probably bears water or pinches out toward the eastward. No oil was shipped from the Midway Field before 1904, when a pipe line was laid from about Sec. 8, T. 32 S., R. 23 E. to Sunset.

In 1901 the railroad was built from Gosford to Sunset, thence to Maricopa in 1904, and in 1909 the branch was extended northward to Fellows, and to Shale in 1911.

The period of most active development and new discoveries began in the early part of 1909. The diagram showing monthly production and number of wells more clearly show the history of development than is possible in any brief description. The wonderful and sudden development of the field was largely due to encouragement given by the bold prospecting policy of the Standard Oil Company who started wells on the following sections: 18, 20 and 30, 32–24, 10 and 14, 32–23 and 26, 31–23, and also built a pipe line from Bakersfield. This prospecting placed the Standard Oil Company in its present rank as an owner of proved oil land.

Among the first notable discoveries of oil in new territory were those by the Hawaiian Oil Company, on section 31, 31–23, the Bear Creek Oil Company, on 14, 31–22. An enormous quantity of gas was struck by the Honolulu Oil Company, on section 14, 32–24, and a little later by the Standard Oil Company, on 26, 31–23. During the early part of 1910 many wells struck oil and recounting their sequence would be difficult and unprofitable. The most notable well was the Lakeview (Union Oil Company), 25, 12–24, which flowed from 20,000 to 40,000 barrels per day for over a year.

Insecurity of title, due to the fact that there was little or no patented land (aside from that belonging to the Southern Pacific Company), and that the law regulating placer mining had to be stretched almost to the breaking point, made operations doubly hazardous. After development was commenced the federal government withdrew the land from entry. Future disposal of these government lands will be a very delicate problem in view of the fact that most people who were not present during the early stages of development fail to realize the great hazard entailed in wildcat operations where the district was practically an uninhabited desert.

Late in 1910 development began in the Elk Hills in the hope that the broad anticline would be a duplicate of the Buena Vista Hills. A number of wells were drilled, some of which struck a grade of oil above 18°, while others were barren.

The federal government has sued the Southern Pacific Company to regain title to land in the Elk Hills, under plea that it is mineral land. The most promising results were obtained by the Associated Oil Company working under the advice of W. A. Williams. The company is controlled by the Southern Pacific Company, and the complications attending the suit have brought forward much conflicting testimony as to the value of the land. Doubtless the future will see oil produced from some parts of the Elk Hills.

The Elk Hills and the valley between the Buena Vista Hills and Elk Hills has been unsuccessfully prospected with few notable exceptions, by the following wells:

Scottish Oilfields	S.E. ¼ Sec. 22, 30-23, 4,000′	(?)
Associated Oil	N.E. ¼ Sec. 22, 30-23, #1, 1,480′	No oil.
Associated Oil	S.W. ¼ Sec. 22, 30-23, #3, 2,980′	Show of gas.
Associated Oil	S.E. ¼ Sec. 22, 30-23, #4, 1,185′	No oil.
Associated Oil	N.E. ¼ Sec. 24, 30-23, #1, 70′	No oil.
Associated Oil	N.W. ¼ Sec. 24, 30-23, #2, 1,291′	No oil.
Associated Oil	S.W. ¼ Sec. 24, 30-23, #3, 3,887′	100 bbls. oil, 3,000,000 ft. gas.
Associated Oil	S.E. ¼ Sec. 24, 30-23, #4, 1,187′	No oil.
Associated Oil	S. ½ Sec. 26, 30-23, #1, 4,027′	45 bbls. 38° B.
Associated Oil	N.W. ¼ Sec. 26, 30-23, #2, 332′	No oil.
Associated Oil	N.E. ¼ Sec. 26, 30-23, #3, 518′	No oil.
Associated Oil	S.E. ¼ Sec. 26, 30-23, #4, 460′	No oil.
Hill Crest	S.W. ¼ Sec. 28, 30-23, #1, 1,661′	No oil.
Redlands	N.E. ¼ Sec. 30, 30-23, #1.	
Midway Pacific	S.W. ¼ Sec. 32, 30-23, #1, 2,425′	Abandoned.
Mercedes	N.E. ¼ Sec. 10, 31-23, #1, 1,800′	No oil.
Hart	S.E. ¼ Sec. 11, 31-23, #1, 1,895′	No oil.
Comstock Midway	S.E. ¼ Sec. 2, 31-23, #1, 2,000′	No oil.
Carmen	S.E. ¼ Sec. 1, 31-23, #1, 745′	No oil.
Los Angeles Midway	N.W. ¼ Sec. 6, 31-23, #1, 200′	No oil.
Union	S.W. ¼ Sec. 6, 31-23, #1, 3,205′	No oil.
Mays	S.E. ¼ Sec. 8, 31-23, #1, 3,135′	Trace.
Calanava	S.W. ¼ Sec. 1, 31-23, #1, 1,200′	No oil.
Rex Midway	S.W. ¼ Sec. 8, 31-23, #1, 3,373′	Oil and gas.
Barnodon	S.W. ¼ Sec. 14, 31-23, #1, 3,250′	Gas.
Hart	N.E. ¼ Sec. 13, 31-23, #1, 3,055′	No oil.
Union	S.E. ¼ Sec. 24, 31-23, #1, 3,120′	Trace.
Associated Oil	Sec. 30, 30-24, #1, 3,838′	72 bbls. 25° B.
Midway Valley	N.W. ¼ Sec. 12, 31-24, #1, 4,850′	No oil.
Monsoon	S.E. ¼ Sec. 11, 31-24, #1, 1,205′	No oil.
General Petroleum	N.W. ¼ Sec. 10, 31-24, #1, 3,072′	No oil.
Associated Oil	N.E. ¼ Sec. 5, 31-24, #1, 2,128′	No oil, lots of gas.
Elk Hills Oil Co.	N.W. ¼ Sec. 7, 31-24, #1, 3,955′	Trace.
Elk Hills Oil Co.	N.E. ¼ Sec. 8, 31-24, #1, 2,260′	No oil.
Elk Hills Oil Co.	S.W. ¼ Sec. 9, 31-24, #1, 810′	No oil.
Union	N.W. ¼ Sec. 22, 31-24, #2, 3,840′	No oil.
Buena Vista	S.E. ¼ Sec. 14, 31-24, #1, 2,450′	No oil.
Midway Basin	N.W. ¼ Sec. 28, 31-24, #1, 3,123′	No oil.
Triune	S.W. ¼ Sec. 34, 31-24, #1, 4,050′	Trace.
East Midway	S.E. ¼ Sec. 2, 31-24, 1,315′	
Elk Hills Midway	S.E. ¼ Sec. 31, 31-24, 1,415′	
Section Four	Sec. 4, 31-24, 1,050′	
Green & Hutchinson	S.W. ¼ Sec. 4, 31-24, #1, 2,355′	

The land south of the Buena Vista Hills, commonly called "Sunset Flat," has failed to produce oil in paying amounts at the following wells:

El Camino	Sec. 10, 11-23, #1, 4,750′	No oil.
Sunset Security	Sec. 29, 11-23, #1, 3,995′	Oil.
El Cerito	Sec. 35, 11-23, #1, 2,295′	No oil.
Maricopa Producers	Sec. 8, 11-23, #1, 2,165′	Water.
Hazeltine Crude	Sec. 17, 11-23, #1, 1,892′	Trace.
Visalia Maricopa	Sec. 20, 11-23, #1, 1,797′	Trace.
Vancous Paraffine	#1, 2,245′	Trace.
Sunset Extension	Sec. 8, 11-23, #1, 3,540′	Trace.

Future development may extend the present proved area (as shown on Plate XI), a short distance northeast from the Buena Vista Hills, and also in places along the crest of the Elk Hills. Otherwise the area is not likely to expand, judging by present developments and known geologic conditions.

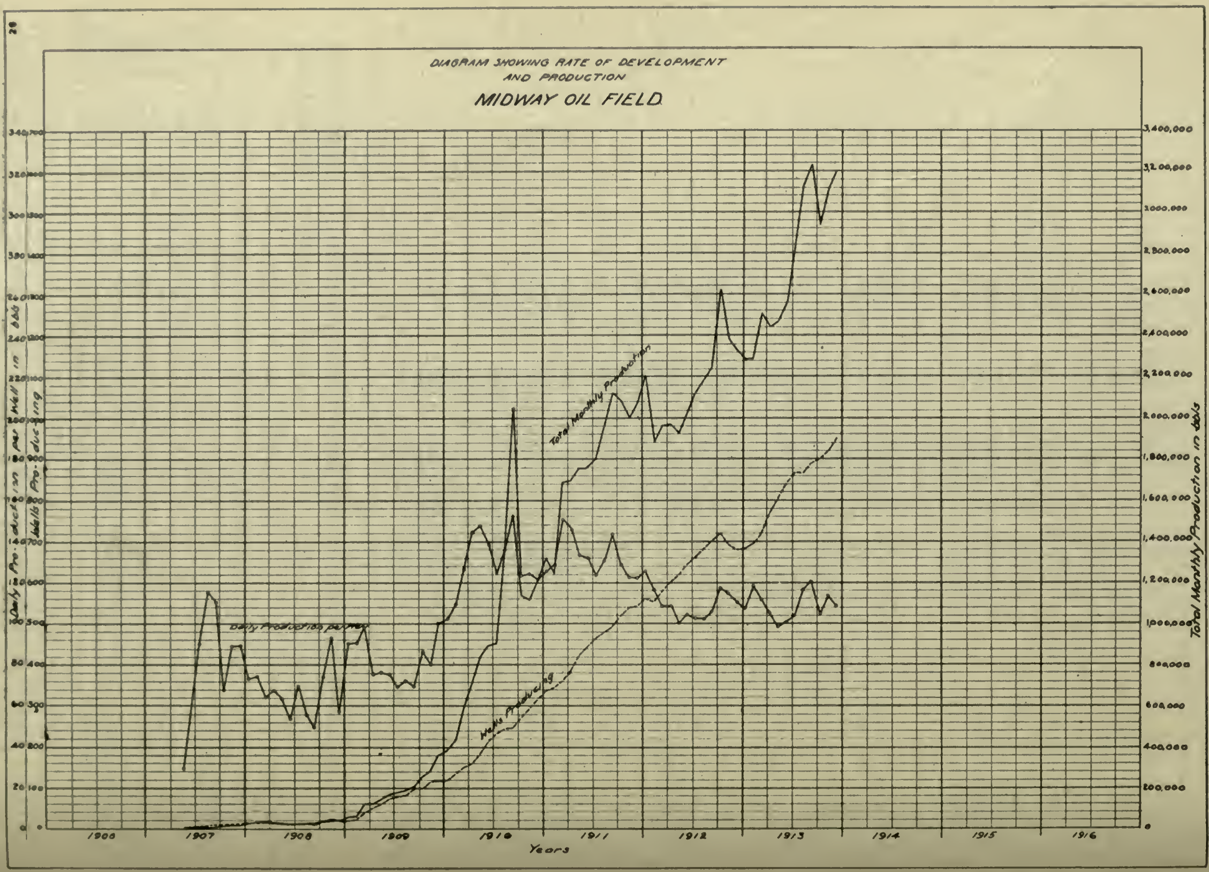


DIAGRAM SHOWING RATE OF DEVELOPMENT
AND PRODUCTION
MIDWAY OIL FIELD
Daily Pro-duction per Well in bbls
Wells Pro-ducing
340 1700
320 1600
300 1500
280 1400
260 1300
240 1200
220 1100
200 1000
180 900
160 800
140 700
120 600
100 500
80 400
60 300
40 200
20 100
0 0
Total Monthly Production in bbls
3,400,000
3,200,000
3,000,000
2,800,000
2,600,000
2,400,000
2,200,000
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
Years
Total Monthly Production
Daily Production per Well
Wells Producing
28

Fig. 28.

There may be some future extension along the base of the hills southeast from Sunset, as a few wells have struck a little very light oil. There is little or no reason to expect extension of the main area towards the southwest nor towards the northwest, in the areas of brown shale (Monterey).

History of development and rate of production in the Midway Field since 1903 is well shown by the accompanying diagram, made up largely from figures supplied by the Standard Oil Company.

Previous to 1909 there had been some activity, principally on Twenty-five Hill, the total monthly production being less than 50,000 barrels. There were some twenty producing wells averaging from sixty to one hundred barrels per day.

1909 to 1913.—During 1909 activity in drilling began and a great deal of new territory was proved; by the close of the year producing wells were being added at the rate of 208 per year. This drilling campaign was continued with great regularity to the end of 1913.

The total production of the field has steadily increased during this period from about 400,000 barrels per month to 3,200,000 barrels, and may be expected to increase still further.

The rate of production per well has been somewhat erratic as gushers, producing several thousand barrels per day, have been frequently struck at distances so far apart that they have little or no effect upon each other. However, it will be noted that there is a marked decline since 1910, when the average well produced about 130 barrels per day, until 1913 when the average was about 110 barrels, the rate of decline being about 8.5 barrels per year.

The future of the field can not be so definitely stated as is the case with some other fields (see Coalinga, page 125, and Kern River, page 204) as the amount of undrilled land is large and a steady rate of decline in well production has not been definitely established. However, the oft-repeated statement that wells will decline very rapidly should be accepted with considerable reluctance in view of our present figures. The very quick decline of the abnormally large gushers has doubtless given an exaggerated idea of the shortness of life.

Including the Sunset Field, which is naturally not separated from Midway, there is a total proved area of about 59 square miles, with 1,222 producing wells, or an average of 30.8 acres per well.

It is probable that the two fields will economically support three or four times as many wells as now exist. Since 1903 the total production of the fields has been 126,558,111 barrels or only 3,350 barrels per acre of proved land. Of course this latter figure has but little significance owing to the great area of proved land which has not yet produced much oil. However, it does indicate that the ultimate production may be reasonably expected to be at least five or ten times the amount already produced.

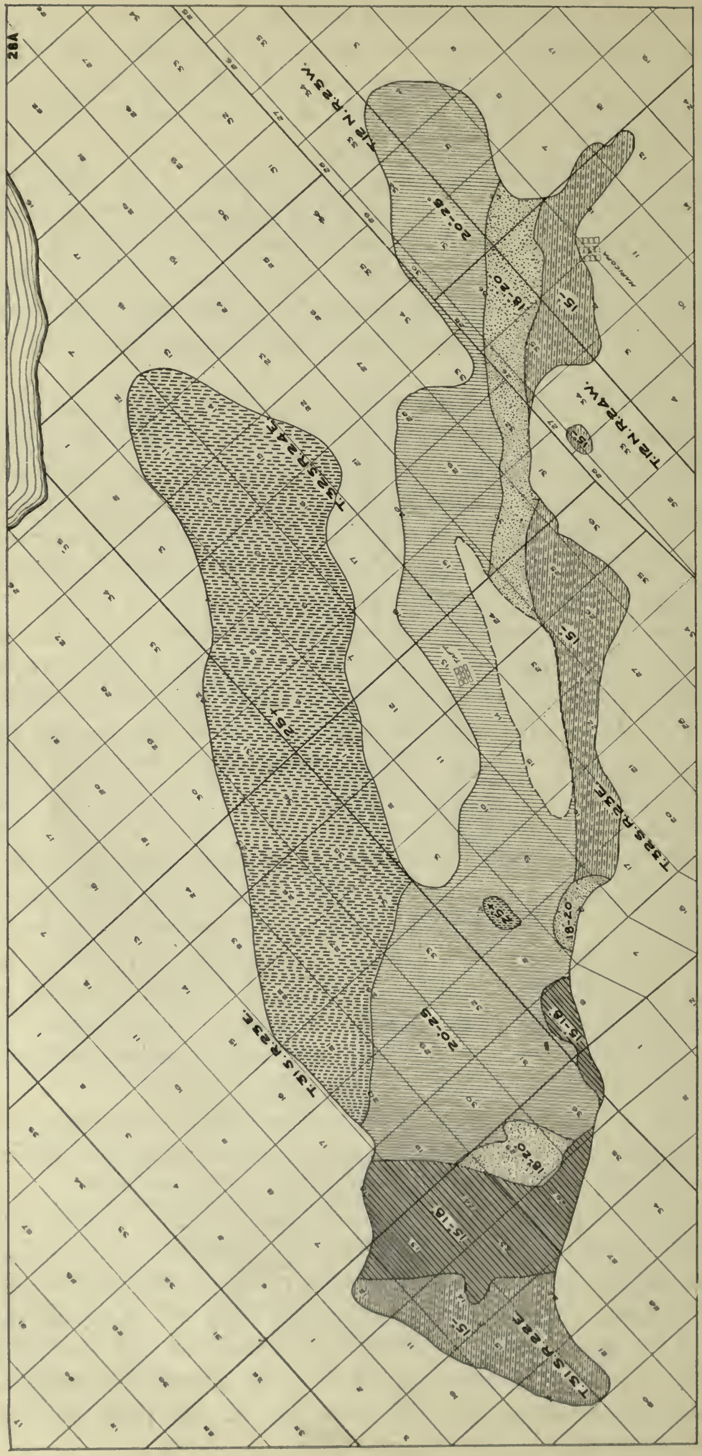


Fig. 28A. Proved Oil Land and Gravity of Oil. Midway-Sunset Field.

STATISTICS OF FIELD DEVELOPMENTS.

(Standard Oil Company.)

Midway Field.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1907.				
January				
February				
March				
April				
May	4		3,700	30
June		1		
July	7	1	19,800	91
August	6		21,600	116
September	7	2	23,250	111
October	10		21,030	68
November	11	3	29,750	90
December	11		30,814	90
Totals		7	149,944	
1908.				
January	16	1	36,580	74
February	16	1	34,765	75
March	17	5	34,461	65
April	15	5	30,660	68
May	16	2	31,930	64
June	16	1	25,980	54
July	15	3	32,550	70
August	19	4	33,077	56
September	17	1	25,740	50
October	20	2	46,500	75
November	21	7	59,400	94
December	24	3	42,935	58
Totals		35	434,578	
1909.				
January	22	6	62,310	91
February	26	8	66,640	91
March	43	10	131,750	99
April	56	8	127,950	76
May	63	12	150,085	77
June	77	12	175,075	76
July	81	11	187,040	70
August	86	8	195,440	73
September	100	9	212,029	70
October	101	15	264,854	87
November	119	9	289,469	81
December	119	15	371,813	101
Totals		123	2,234,455	
1910.				
January	121	15	388,522	103
February	139	11	429,501	110
March	153	16	603,006	127
April	164	18	715,002	145
May	185	23	851,785	148
June	216	13	902,732	139
July	233	28	911,639	126
August	247	14	1,360,325	177
September	248	25	1,539,584	207
October	276	27	1,145,003	134
November	298	26	1,118,418	125
December	318	22	1,208,690	122
Totals		238	11,174,207	

Midway Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1911.				
January	339	27	1,324,073	126
February	348	16	1,252,241	129
March	361	30	1,696,316	151
April	389	30	1,703,812	146
May	424	28	1,765,888	134
June	447	25	1,768,973	132
July	469	22	1,807,840	124
August	481	23	1,957,396	131
September	494	29	2,132,651	144
October	522	25	2,092,075	129
November	542	12	2,004,945	123
December	546	28	2,078,392	123
Totals	------------	295	21,584,602	
1912.				
January	564	16	2,215,350	126
February	556	18	1,890,946	117
March	581	20	1,968,633	109
April	602	22	1,978,551	109
May	620	23	1,932,686	101
June	644	21	2,032,838	105
July	665	22	2,129,646	103
August	682	24	2,182,187	103
September	705	19	2,249,451	106
October	723	28	2,639,286	118
November	695	21	2,393,608	115
December	681	28	2,335,798	111
Totals	------------	262	25,948,980	
1913.				
January	685	20	2,290,282	108
February	697	19	2,294,613	119
March	722	14	2,520,729	112
April	770	17	2,444,467	106
May	808	16	2,472,977	99
June	844	28	2,559,843	101
July	870	27	2,813,167	104
August	867	16	3,141,001	117
September	891	13	3,237,795	121
October	903	17	2,940,669	105
November	921	13	3,121,010	114
December	952	12	3,203,576	109
Totals	------------	212	33,040,129	
Total completed	------------	1,172		
Idle or abandoned	------------	224		

FINANCIAL RESULTS.

Financial results in the Midway field during the year 1913, as shown by fifty-nine companies, producing 15,861,884 barrels of oil from 624 wells, are summarized as follows:

Capital. This figure can not be definitely determined, particularly the second item (property value) and any error here is apt to be on the side of an overestimate.

Cash paid for stock	$3,891,763 00
Property paid for stock	12,110,051 00
Total	$16,001,814 00

Dividends are difficult to determine as many concerns are close corporations, making no public reports, hence our figures may be slightly below the actual amounts. Records earlier than 1909 were not available.

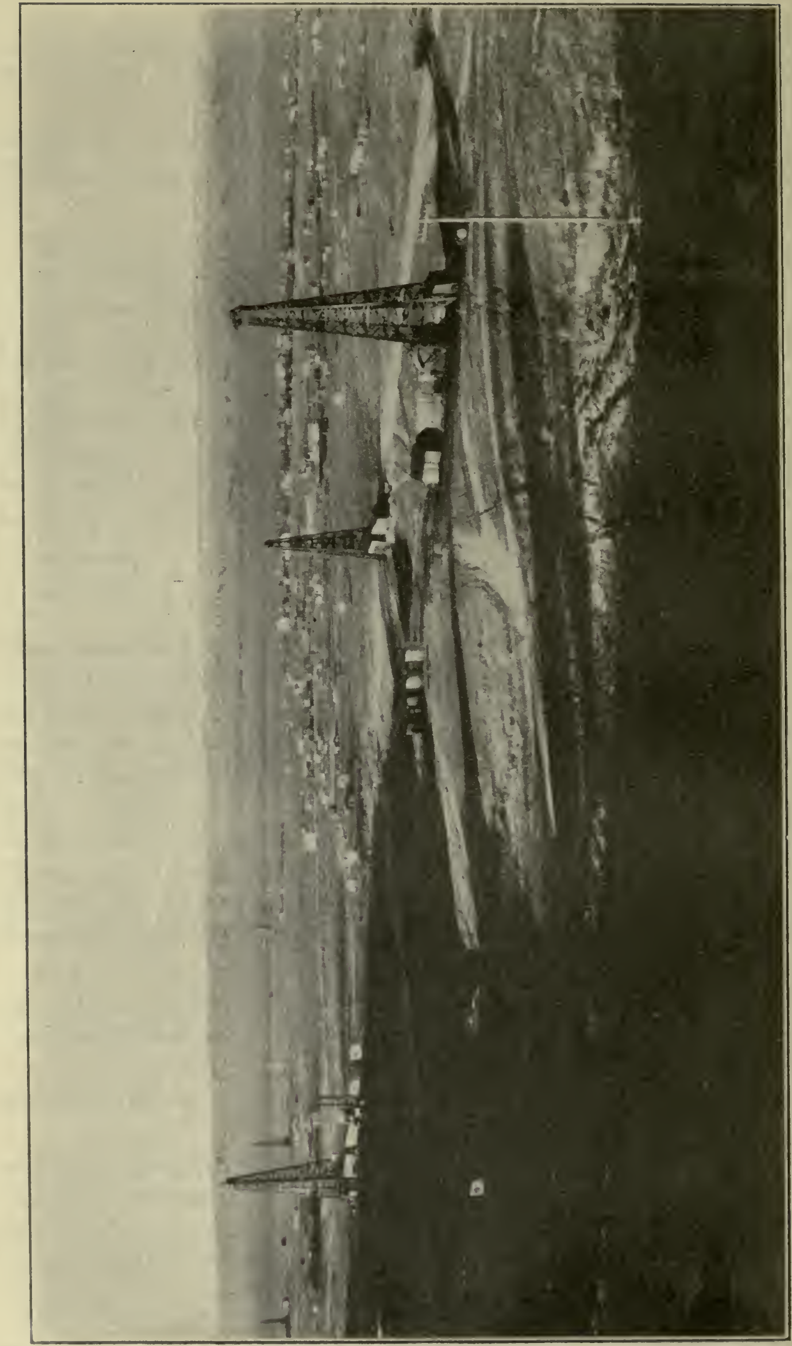
1909— 4 companies	$101,000 00
1910—10 companies	562,763 00
1911—18 companies	1,076,285 00
1912—19 companies	1,128,161 00
1913—14 companies	520,520 00
	$3,388,729 00

As the field is comparatively new there are only three companies who have paid dividends continuously since 1909. However, there are nine companies who have paid continuously for the past three years, and their operating conditions during 1913 are summarized as follows: Two merely received royalty. The total number of wells was 70, producing about 1,400,000 barrels of oil, 4 per cent of the field total. Most of these companies were producing about 14° B. oil, their average price being 38 cents. Their dividends aggregated $390,817, or 75 per cent of the year's total. Their average operating expense per well per day was $9.72, or 17.8 cents per barrel, including everything except the fixed charges such as taxes, insurance and depreciation.

Production of all the companies paying dividends in 1913 was 1,867,000 barrels, or 6 per cent of the field total, with an average price of 52.1 cents.

Other facts of interest in this connection appear in the table on page 10.

Some figures showing the general condition of the business as it has been carried on during 1912 are made up from the operation of eighty-three companies. The total production of eighty companies in 1912 was 16,527,519 barrels from 655 producing wells, which was 64 per cent of the total output of the field.



Portion of the Midway oil field, showing town of Taft and the Buena Vista Hills. Photograph by R. B. Moran.

The production during 1912 by the twenty-five which have at some time paid dividends was 6,881,142 barrels, of which 280,173 barrels were produced by the four companies paying dividends continuously for the four years.

Cash to the amount of $6,031,700 was received for the oil, or an average price of 36½ cents per barrel.

Price and amount of various grades of oil during 1912 were reported about as follows:

Under 15° B.	37.50 per cent at 40.4 cents per barrel
15.1° to 18° B.	3.40 per cent at 34.4 cents per barrel
18.1° to 20° B.	31.70 per cent at 35.2 cents per barrel
Above 20° B.	27.40 per cent at 40.7 cents per barrel

Total operating expense (not including depreciation, taxes, insurance, and interest, which are here referred to as fixed charges) was $4,243,422, averaging $17.65 daily per well, or 25.6 cents per barrel. The daily operating expense per well of twenty-four of the dividend paying companies with 295 wells was $11.90 and was $2.94 for forty-five wells of three companies that paid during all four years. These figures include costs on 86 wells drilling and 655 producing.

Daily production per well, from the figures under consideration, show the average for the field to have been 69.2 barrels, and for the companies that paid dividends, 62.5 barrels.

GEOLOGY OF THE MIDWAY-SUNSET DISTRICT.

The geology of the Midway-Sunset District is somewhat obscure, and it is only after thoroughly cross-sectioning the region that conclusions can be reached with certainty. The formations are best exposed in the canyons of the Temblor Range which, as a rule, cut across the strike of the formations.

The general structure of the region consists of a system of parallel folds extending northwest to southeast, parallel to the Temblor Range. The folding is most intense in the Temblor Range, where the dips are often vertical. On the northeastern flank of the range the formations dip northeastward as a gentle monocline. The southern end of the monocline pitches to the south and is lost in the valley to the southeast of Twenty-five Hill (25, 32–23). The folds become broad and gentle in the Buena Vista and Elk hills to the northeast.

The Monterey formation is the oldest exposed in the region. It consists principally of diatomaceous and siliceous shales which have been intensely folded. These shales are usually of a brown color when fresh and unexposed to weathering. They are usually readily recognized by the drillers, who refer to it as "brown shale." It is doubtful if oil in quantity will here be found in the Monterey, although it is at Santa

Maria. The oil is thought to have been derived from these shales by slow distillation and accumulated usually in the overlying sandstone formations.

Some oil possibly accumulates in the upper strata of the Monterey formations, the fractures in which form reservoirs. The oil does not, however, extend to any depth. These upper shales are usually soft and chalky.

In some instances the oil has possibly been forced downward by water or gas pressure, but these instances are governed by special cases of geologic structure.

The Santa Margarita formation is not known to be represented in the district. Certain shales formerly mapped as Santa Margarita (U. S. Geol. Surv., Bul. 406, pp. 55–56, 69 and 71) in this district are not to be correlated with the Santa Margarita shales of the Cholame Valley region. *Venericardia montereyana, Phacoides acutilineatus* Conrad, and a small crustacean found by C. A. Waring in the chalky, diatomaceous shale just below the Etchegoin conglomerate beds, show these shales to be of Monterey age.

The Jacalitos formation is in places exposed beneath the Etchegoin. It consists of interbedded shales and sandstones with *Trophon ponderosus* Gb. and *Astrodapsis tumidus* Remond.

The Etchegoin formation overlies the Monterey shales unconformably. The nonconformity is an overlap and the lowest beds are not exposed in the district. Fragments of *Paphia staleyi* Gabb blown from gas wells in the Buena Vista Hills show that the lowest beds yet drilled into in that part of the field are of Etchegoin age.

Along the contact of the Monterey and Etchegoin formations on the east flank of the Temblor Range, the lowest exposed beds of the Etchegoin consist of about 250 feet of loosely consolidated coarse bluish-gray, granitic sandstone, conglomerate and boulders. These conglomerates are overlain by brownish gypsiferous sands and clays. Some of the conglomerate contains a few waterworn Monterey shale pebbles. The beds are often cross-bedded and are greatly thickened northward by overlapping of later Etchegoin beds. A shark's tooth of the species *Charcharodon arnoldi* Jordan was taken from Eagle Creek Well No. 2 in Sec. 31, T. 31 S., R. 23 E. at a depth of 1,910 feet. These teeth are common in the Etchegoin formation.

The Tulare formation lies unconformably on the Etchegoin formation. This unconformity is well exposed in the canyon near the line between Secs. 21 and 22, T. 32 S., R. 23 E. The formation consists of loosely consolidated sandstone, and conglomerate, made up almost entirely of Monterey shale pebbles. In the valleys it is overlain by alluvium.

Oil Horizons. In the region east of Fellows the oil occurs in the Etchegoin formation, which dips about 30° to the northeast and is flexed

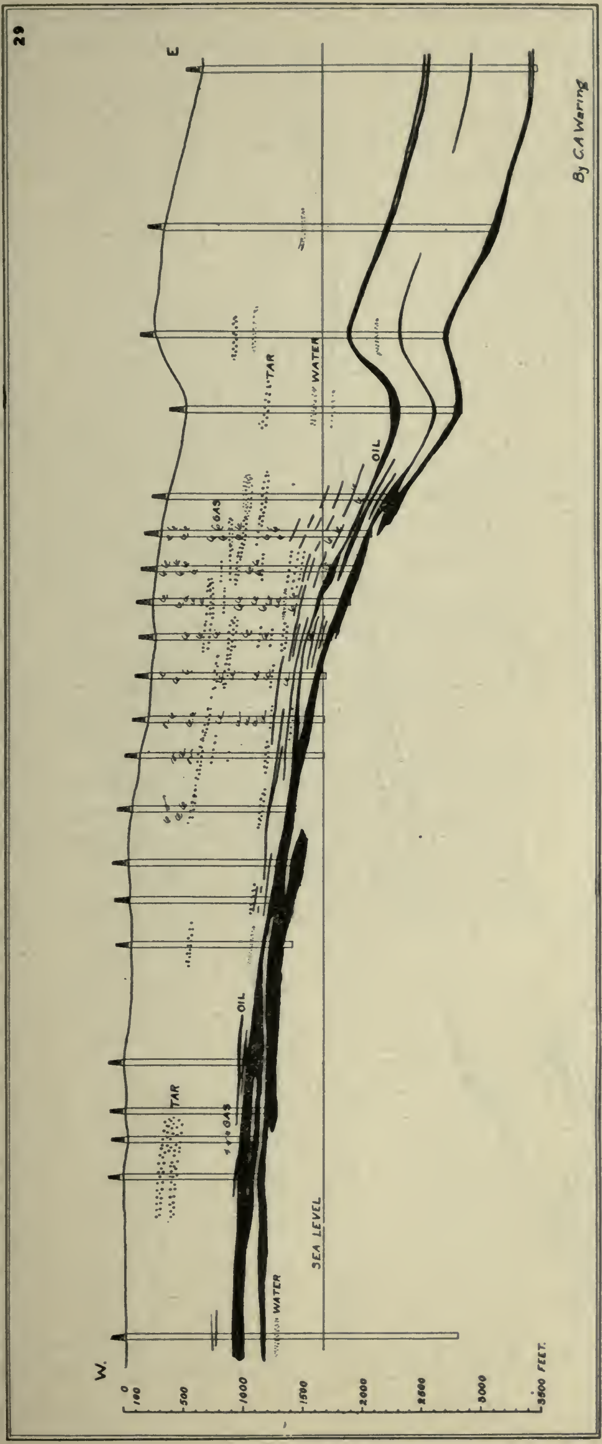


Fig. 29. Geologic cross section through Twenty-five Hill. Midway Field. (See page 231.)

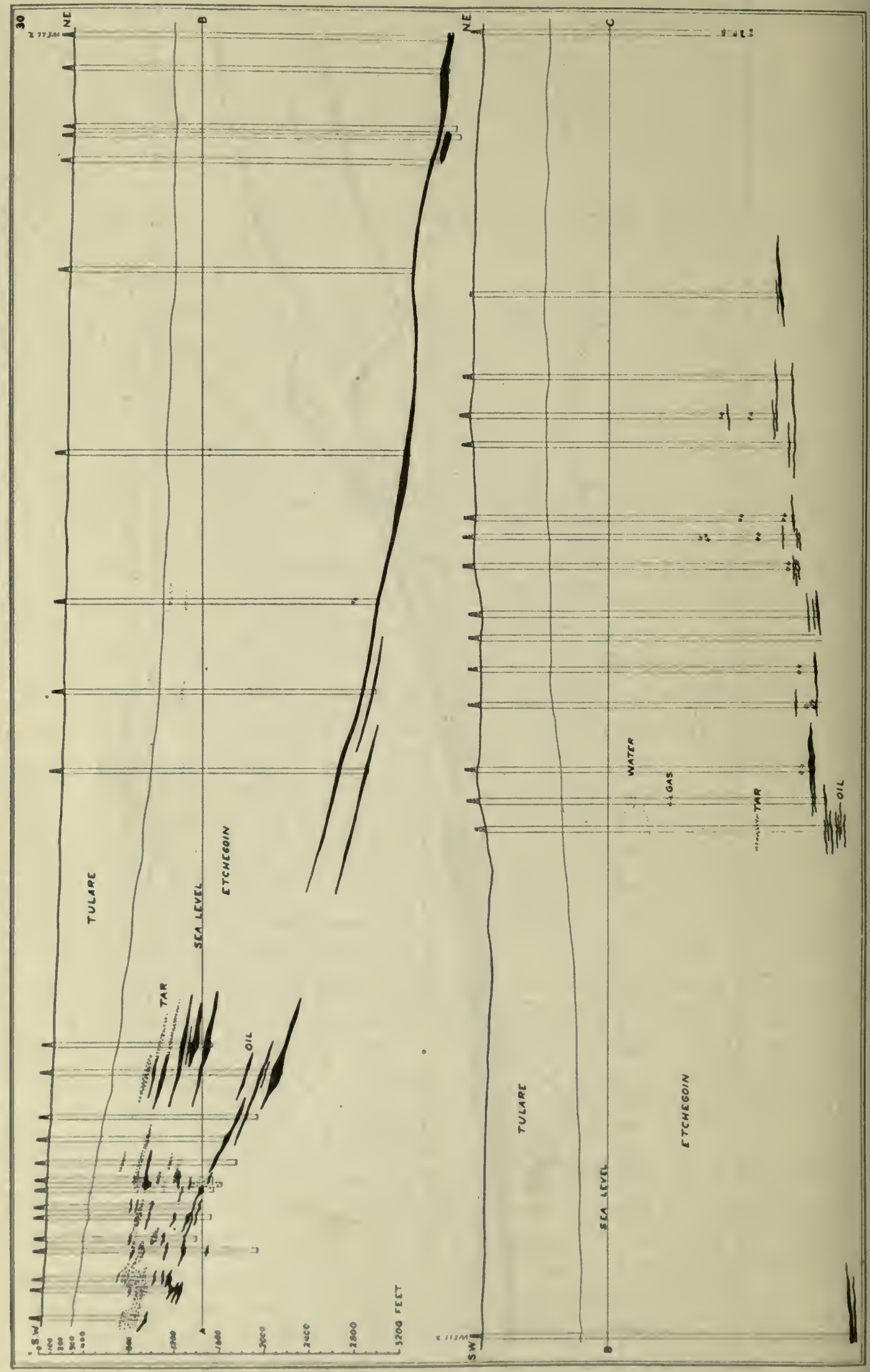


Fig. 30. Geologic cross section in the Midway Field, from Sec. 6, T. 32 S., R. 23 E. to Sec. 33, T. 31 S., R. 23 E.

into a broad syncline in the Midway Valley and an anticline in the Buena Vista Hills. The cross-section, Fig. 30, shows the relative depths at which this oil formation may be expected. The wells must, of course, be drilled deeper the farther they are from the outcrop along the dip, until the beds begin to rise along the anticline.

In the region about Twenty-five Hill two oil horizons (see cross-section Fig. 29) are found. The lower one dips more steeply to the eastward than the upper, which is in the Etchegoin formation and overlaps it unconformably. The lower horizon may be in the Jacalitos formation.

The geologic structure in the region of Kerto represents similar conditions. Close to the Temblor Range only one oil sand, the upper, is present and deeper drilling shows Monterey shale below. Farther to the east in Sec. 32, T. 12 N., R. 23 W. and Sec. 4, T. 11 N., R. 23 W., there are two oil horizons about 300 feet apart.

The accompanying cross-sections and underground contour map illustrate the geologic conditions. The contour map represents the approximate position of the top of the productive oil sands but not necessarily the same geologic horizon throughout the field. As a general rule the upper oil sands are thicker and carry oil lower than 18° B. under slight gas pressure. The lower sand is in most places less than 100 feet thick, produces oil lighter than 18° B. and is frequently under gas pressure of several hundred pounds. It has supplied many of the gushers of the field. (See figures, pages 229 and 230.)

In the Buena Vista Hills present developments indicate that the crest of the anticline carries oil in approximately the same horizon as the "lower sand" of the main field. In some places in the Buena Vista Hills, however, the horizon is filled with gas under pressure of several hundred pounds. A number of wells drilled through gas sand and into oil indicate that in general the gas has collected along the anticline in higher beds.

DIRECTORY OF COMPANIES OPERATING IN MIDWAY FIELD.

Company	Location	Wells completed	Gravity	Official address
*Alberta	14-31-22	5	13.2	Bakersfield.
Alaska Pioneer	32-31-23	7	25.2	433 Mills Bldg., San Francisco.
*American Oil Fields	12-31-22	--------	--------	603 Security Bldg., Los Angeles.
American Oil Fields	36-31-22	39	22.0	
American (Midland)	16-32-23	7		
American	32-32-24	8		
Amber	26-31-22	1		
August	31-32-24	1	--------	Box 838, Fresno.
Associated Oil Co.	24-30-23	1	--------	Sharon Bldg., San Francisco.
Associated Oil Co.	26-30-23	1		
Associated Oil Co.	30-30-24	1		
Associated Oil Co.	20-31-23	2		
Associated Oil Co.	22-31-23	1	29.5	
Associated Oil Co.	26-31-23	3		
Associated Oil Co.	30-31-23	6	22.5	
Associated Oil Co.	32-31-23	2	22.7	
Associated Oil Co.	34-31-23	4	26.5	
Associated Oil Co.	35-31-22	5	16.5	
Associated Oil Co.	5-31-24	5		
Bankline	15-31-22	6	15.0	
Bankline	36-32-23	2	15.0	
Baltimore	28-32-24	1	25.0	512 Union Oil Bldg., Los Angeles.
*B. H. & C.	25-32-23	6	14.2	208 Brower Bldg., Bakersfield.
*Boston Pacific	32-31-24	1	24.4	Sharon Bldg., San Francisco.
Boust	23-32-23			
Brookshire	24-31-22	3	17.5	
*Brad	15-32-23	2	16.5	Taft.
Buena Vista	14-31-24	--------	--------	1504 Chronicle Bldg., San Francisco.
Buick	--------	--------	--------	(See General Petroleum.)
Burks	22-32-23	3		
California Amalgamated	28-31-23	2	23.7	Taft.
California Counties	4-32-23	4	26.3	85 Second st., San Francisco.
California Midway	32-31-23	6	22.3	400 H. W Hellman Bldg., Los Angeles.
California Oil Lands	31-32-25	--------	--------	443 Mission st., San Francisco.
*California Seaboard	25-32-23			
California Crude	31-32-24			
Carmen	1-31-23			
Caribou	28-31-23	3	27.5	433 Mills Bldg., San Francisco.
*Carbo	26-32-23	10	14.0	Box 34, Bakersfield.
Calanava	8-31-23			
Canadian Pacific	4-32-23	2	24.3	Box 63, Midland.
*Cheney & Stimson	23-32-23	6	14.0	
Coalinga Monterey	24-31-22	3	17.5	Salinas.
Colidon	19-31-23	1		
Coin	4-31-22			
Columbia Midway	32-31-23	--------	--------	Midland.
Combination Midway	22-32-23	1		
*Combined	14-31-22	6	13.0	
Consolidated Midway Chief	15-32-23	2	16.5	
Creseus	25-32-23	9	15.0	577 I. W. Hellman Bldg., Los Angeles.
D. B. T.	34-32-34			
Dome (Pinal-Dome)	23-31-23	11	18.6	Santa Maria.
*Dominion	15-31-22	4	15.6	508 Postal Telegraph Bldg., San Francisco.
*Dunlap	26-32-23	7	14.0	
Durango	20-31-22			
Eagle Creek	31-31-23	7	23.3	Fellows.
East Midway	2-31-24			
Edmunds Midway	32-32-24	2	20.5	605 Security Bldg., Los Angeles.
Elk Hills	7-31-24			
Elk Hills	8-31-24			
Elk Hills	9-31-24			
Elk Hills Midway	2-31-24			
Elkhorn	25-32-23	3	15.0	
Elliott, Susan	15-31-22	2	15.0	

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Companies Operating in Midway Field—Continued.

Company	Location	Wells completed	Gravity	Official address
Engineers	14-31-22	5	20.3	712 Security Bldg., Los Angeles.
Empire Gas and Fuel	15-31-22	7	15.5	
Empire Gas and Fuel	15-32-23	2	17.0	
Extension	34-32-24	--------	--------	417 Chamber of Com. Bldg., Los Angeles.
Fairbanks	22-32-23	7	15.0	2108 Shattuck ave., Berkeley.
*Fairfield	11-31-22	--------	--------	308 Columbia Trust Bldg., Los Angeles.
*Fairfield	13-31-22	5	17.5	
Fairfield	19-31-23	1	17.5	
Fifty	10-31-22			
Fox	--------	--------	--------	
Francis, Millie	25-32-23	3	15.0	
General Petroleum	26-31-22	2	--------	Higgins Bldg., Los Angeles.
General Petroleum	23-31-22	8	17.0	
General Petroleum	10-31-24			
General Petroleum	32-31-24	1	26.5	
General Petroleum (Buick)	32-31-23	5	22.4	
General Petroleum	14-32-23	3		
General Petroleum	15-32-23	1		
General Petroleum	15-31-22	26	15.5	
General Petroleum	25-32-23	24	15.0	
General Petroleum	26-32-23	16	15.0	
General Petroleum	12-31-22	1	16.0	
General Petroleum	32-32-24	3		
General Petroleum	14-31-22	17	16.0	
General Petroleum	13-31-22	3	16.5	
General Petroleum	22-32-23	4	15.0	
*Globe	--------	--------	--------	
Golden Gate	36-32-24			
Graham	25-32-23			
Green-Hutchison	4-31-24			
Griffith Crude	23-32-23			
Greenleaf	30-31-24			
Hale-McLeod	5-32-23	8	22.0	925 Storey Bldg., Los Angeles.
Hale-McLeod	8-32-23	3	18.0	
Hart	3-31-23			
Hart	11-31-23			
Hart	13-31-23			
Hart & Shannon	28-31-24			
Hart & Shannon	6-31-24			
Hayden	26-32-23	5		
*Hondo	15-31-22	6	15.2	1130 Van Nuys Bldg., Los Angeles.
Honolulu Consolidated	31-31-23	15	22.5	268 Market st., San Francisco.
Honolulu Consolidated	4-32-24	2	23.0	
Honolulu Consolidated	6-32-24	4	30.0	
Honolulu Consolidated	8-32-24	5	28.0	
Honolulu Consolidated	10-32-24	1	27.0	
Honolulu Consolidated	12-32-24	2	26.0	
Honolulu Consolidated	14-32-24	4	23.0	
*Indian Colonial	22-32-23	22	13.5	Taft.
Jade	15-32-23	1	--------	805 Security Bldg., Los Angeles.
J. M. S.	26-32-23	6	15.0	
Kalispel	5-32-23	3	21.0	Bakersfield.
Kanawah	15-32-23	1	--------	Taft.
Kern Crown	23-32-23	9	21.0	Kern.
Kern Midway	31-31-24			
K. and C.	21-31-22	1		
Kline	31-32-24			
Knickerbocker	32-32-24	1	--------	60 California st., San Francisco.
*Knob Hill	23-32-23	3	--------	1241 I st., Fresno.
Kern Trading and Oil	1-32-23	6	--------	Flood Bldg., San Francisco.
Kern Trading and Oil	3-32-23	2	26.5	
Kern Trading and Oil	5-32-23	9	23.0	
Kern Trading and Oil	13-32-23	3	23.0	
Kern Trading and Oil	5-32-24	2		
Kern Trading and Oil	7-32-24	1		
Kern Trading and Oil	9-32-24	1		

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Companies Operating in Midway Field—Continued.

Company	Location	Wells completed	Gravity	Official address
Kern Trading and Oil	11-32-24	4		Flood Bldg., San Francisco.
Kern Trading and Oil	17-32-24	2		
Kern Trading and Oil	19-32-24	4	--------	
Kern Trading and Oil	29-32-24	2	24.0	
Kern Trading and Oil	33-32-24	3		
Kern Trading and Oil	15-31-22	11	15.0	
Kern Trading and Oil	23-31-22	12	17.0	
Kern Trading and Oil	25-31-22	5	20.0	
Kern Trading and Oil	27-31-23	1		
Kern Trading and Oil	33-31-23	1		
Kern Trading and Oil	35-31-23	3	25.0	
Lakeview Annex	26-32-24			
Lakeview No. 2	26-32-24	1		
Lakeside	26-31-24			
Lockhart	6-31-24			
Los Angeles Midway	6-31-24	--------	--------	321 I. W. Hellman Bldg., Los Angeles.
Los Pasos	36-32-23			
Luxor	32-32-24	--------	--------	219 Sansome st., San Francisco.
Mammoth	31-31-23	6	22.6	Crocker Bldg., San Francisco.
Manchuria	26-31-22	1	--------	95 Market st., San Francisco.
Manitoba Crude	26-32-24	--------	--------	928 Central Bldg., Los Angeles.
*Manhattan Midway	32-32-24	3	--------	901 Union Trust Bldg., Los Angeles.
Manley & McGinn	--------	--------	18.3	
Maple Leaf	22-31-24			
Maricopa	22-31-24	--------	--------	219 Sansome st., San Francisco.
Marion	15-32-23	1		
Mascot	26-32-23	39	14.4	577 I. W. Hellman Bldg., Los Angeles.
Maxwell	26-31-22			
Mays Consolidated	--------	--------	--------	(See North American.)
McKittrick Oil and Light	21-31-22	1	--------	Mills Bldg., San Francisco.
Mercedes	10-31-23			
*M. G. P.	14-31-22	4	15.0	
M. H. M.	15-31-22	4	15.5	
M. H. M. Dev. Co.	14-31-22	5	16.5	
Midas	32-32-25			
Midland	--------	--------	--------	(See American Oilfields.)
Midway Alliance	30-32-25	--------	--------	933 Phelan Bldg., San Francisco.
Midway Basin	28-31-24	--------	--------	703 Union Trust Bldg., Los Angeles.
Midway Chief	4-31-22			
Midway Pacific	24-31-22	3	17.5	406 Storey Bldg., Los Angeles.
Midway Five (P. C.)	5-32-23	4	23.0	605 Storey Bldg., Los Angeles.
Midway National Crude	11-31-23	--------	--------	318 Bradbury Bldg., Los Angeles.
*Midway Peerless	15-31-22	7	15.0	Box 441, Bakersfield.
Midway Provident	20-31-24	--------	--------	403 Storey Bldg., Los Angeles.
Midway Premier	5-32-23	9	22.8	Fellows.
Midway Royal	19-31-23	1	20.0	1008 Security Bldg., Los Angeles.
Midway Syndicate	4-32-23	3	23.4	1033 Union Bldg., Los Angeles.
Midway Valley	12-31-24	--------	--------	810 Security Bldg., Los Angeles.
Mocal	26-31-22	2	17.0	
Monsoon	11-31-24			
Mt. Diablo (North American)	26-32-23	--------	--------	517 Central Bank Bldg., Los Angeles.
North American Cons.	16-32-23	25	15.0	80 Post st., San Francisco.
North American Cons.	22-32-23	54	15.0	
North American Cons.	26-32-23	32	15.0	
North American Cons.	2-32-23	3	25.0	
North American Cons.	30-31-23	4	22.5	
North American Cons.	28-31-23	8	22.5	
National Oil and Gypsum	27-31-22			
Northern Exploration	16-32-24	1		
Oakland Midway	13-31-22	4	16.0	459 Ninth st., Oakland.
*Olig Crude	32-31-23	4	23.0	112 Market st., San Francisco.
Onisbo	14-31-22	1	14.5	Fresno.
Opal	25-32-23	1	--------	629 Citizens Bank Bldg., Los Angeles.
Pacific Crude	26-32-23	4	15.0	112 Market st., San Francisco.
Pacific Crude	32-31-23	3	24.0	
Palmer Union	23-32-23	7	15.0	609 Crocker Bldg., San Francisco.
*Paraffine	25-32-23	6	13.9	Box 566, Bakersfield.
Pierpont	25-32-23	10	14.1	149 N. Los Angeles st., Los Angeles.
Pinal-Dome	--------	--------	--------	(See Dome.)
Petroleum Products	4-31-22			

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Companies Operating in Midway Field—Continued.

Company	Location	Wells completed	Gravity	Official address
Petroleum, North Midway	16-32-24	--------	--------	Crocker Bldg., San Francisco.
Potter, Reid & Taylor	4-31-24			
Princeton	25-32-23	4		
Pyramid	26-31-22	2	18.0	933 Phelan Bldg., Los Angeles.
Pyramid	28-32-24	1	24.4	
Record	28-31-23	2	27.0	433 Mills Bldg., San Francisco.
Recovery	25-31-22	4	20.7	318 Crocker Bldg., San Francisco.
Redlands	30-30-23			
Result	26-31-22	2	18.0	
Rex Midway	8-31-23	--------	--------	805 H. W. Hellman Bldg., Los Angeles.
Rock	23-31-22	8	17.0	916 Title Insurance Bldg., Los Angeles.
*Safe	25-32-23	4	13.7	208 Brown Bldg., Bakersfield.
Santa Fe	22-31-22	2	--------	Kerckhoff Bldg., Los Angeles.
Santa Fe	25-31-22	7	21.0	
Santa Fe	26-31-22	1	18.5	
Santa Fe	36-31-22	15	21.0	
Santa Fe	31-31-23	14	22.0	
Santa Fe	1-33-22	10	16.5	
Santa Fe	4-32-23	2		
Santa Fe	6-32-23	19	18.5	
Santa Fe	8-32-23	10	17.0	
Santa Fe	9-32-23	5	20.5	
Santa Fe	10-32-23	3	24.0	
Santa Fe	15-32-23	1	15.0	
Santa Fe	17-32-23	12	14.0	
Santa Fe	21-32-23	9	15.0	
Santa Fe	24-32-23	7	17.0	
Santa Fe	31-32-24	1		
San Francisco Midway	14-31-22	2	18.0	636 Market st., San Francisco.
San Francisco Midway	25-32-23	2	18.0	
Scottish Oilfields	20-30-23			
Section "25"	25-32-23	31	14.8	1503 Nineteenth st., Bakersfield.
Security (Fox)	15-31-22	4	15.0	
Sides	5-31-22			
S. K. D.	15-32-23	1		
South Midway	34-32-24	1	25.0	417 Chamber of Commerce, Los Angeles.
Standard Oil Co.	22-31-23	4	--------	Standard Oil Bldg., San Francisco.
Standard Oil Co.	26-31-23	8		
Standard Oil Co.	28-31-23	1		
Standard Oil Co.	36-31-23	18	24.7	
Standard Oil Co.	10-32-23	10	18.7	
Standard Oil Co.	12-32-23	2	24.5	
Standard Oil Co.	14-32-23	9	23.1	
Standard Oil Co.	24-32-23	4	20.7	
Standard Oil Co.	16-32-24	8	24.7	
Standard Oil Co.	18-32-24	7	21.0	
Standard Oil Co.	20-32-24	4	24.3	
Standard Oil Co.	28-32-24	5	22.7	
Standard Oil Co.	30-32-24	18	19.2	
St. Helens	16-32-24	2	30.0	Los Angeles.
St. Lawrence	5-32-23	6	22.0	Fellows.
State	17-31-22	--------	--------	149 California st., San Francisco.
Stockton Midway	14-31-22	5	20.6	318 Elks Bldg., Stockton.
Syndicate Petroleum	28-32-24	1	23.0	San Luis Obispo.
Tamalpais	25-32-23	4	13.9	Commercial Block, San Francisco.
Toronto Midway	17-31-22	1	--------	519 Storey Bldg., Los Angeles.
*Traders	23-32-23	12	13.0	616 Union Oil Bldg., Los Angeles.
*Traffic	9-32-23	1	19.0	616 Union Oil Bldg., Los Angeles.
*Traffic	16-31-22	1		
Triune	34-31-24			
Tumbador	23-31-22	10	17.6	McKittrick.
*T. W.	25-32-23	5	14.2	Box 34, Bakersfield.
Union	15-32-23	2	--------	Taft.
Union	24-31-23			
Union	31-32-24	1		
Union	34-32-24	2		
Union	34-31-23	5	26.5	
Union	14-32-23	3	25.7	
Union	35-32-23	1		

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Companies Operating in Midway Field—Continued.

Company	Location	Wells completed	Gravity	Official address
United	6-32-23	6	20.0	805 H. W. Hellman Bldg., Los Angeles.
United	20-31-23	2	27.0	
United	24-31-22	2	20.0	
Victor	35-32-23	4	12.5	514 Higgins Bldg., Los Angeles.
Visalia Midway	25-31-22	5	19.2	
Westside	25-32-23	3	15.0	836 H. W. Hellman Bldg., Los Angeles.
Witeford Steams	28-32-23			
*Wilbert	22-32-23	2	13.5	Bakersfield.
Wilbert	26-32-23	8	15.0	
*W. T. M.	26-32-23	6	15.8	Box 34, Bakersfield.
Wilkeshead	4-32-23			
Total		1,176		

*Member Independent Oil Producers' Agency.

Amount of oil produced during 1913 by the various companies is indicated by figures on pages 32, 35, 39, 41.

DRILLING METHODS AND COST.

Drilling conditions in the Midway Field are shown by the following tables of casing records, drilling time and cost.

These indicate no saving in cost by drilling with Rotary tools, and the depreciation of drill stem and other parts is frequently considered 75 cents per foot for Rotary tools, and only 25 cents for Standard tools. Stems usually drill their own length without twisting in two, but in attempting the second hole considerable delay from breakage may be expected. Second-hand 6-inch stem is frequently sold for pipe lines for about 30 cents per foot. However, other conditions than cost usually decide the choice of tools. The Rotary is particularly adapted to soft caving ground and to entering sands containing oil or gas under very heavy pressure. For hard streaks in the ground the Standard tools are probably preferable, and for prospect holes where oil or gas sands are easily passed through without recognition, they are certainly more desirable. Combination rigs using both kinds of tools are frequently better than either single type.

The formations in Midway are soft and largely clay.

Strength of casing in resisting collapse is an important consideration and the following table by R. S. Haseltine (Western Engineering, July, 1912), shows in the last column figures which California practice has shown to be safe, when casing is in good condition.

Table Showing Collapsing Pressures of Lap-welded Steel Casing for Sizes Commonly Used in California.

Size, inches	Weight per foot, pounds	Inside diameter, inches	Outside diameter, inches	Thickness, inches	Collapsing pressure, pounds per square inch	Equivalent water column, feet	Water column (factor of safety 2), feet
4½	15.0	4.500	5.000	0.250	2,944	6,790	3,395
5⅝	20.0	5.370	6.000	0.315	3,160	7,280	3,640
6¼	20.0	6.000	6.625	0.312	2,704	6,230	3,115
	26.0	5.845	6.625	0.390	3,717	8,560	4,280
	28.0	5.775	6.625	0.425	4,167	9,600	4,800
6⅝	20.0	6.437	7.000	0.281	2,093	4,830	2,415
	26.0	6.312	7.000	0.344	2,867	6,600	3,300
	28.0	6.220	7.000	0.390	3,440	7,930	3,965
7⅝	26.0	7.390	8.000	0.305	1,914	4,410	2,205
8¼	28.0	8.015	8.625	0.305	1,680	3,870	1,935
	32.0	7.935	8.625	0.345	2,080	4,790	2,395
	36.0	7.875	8.625	0.375	2,383	5,490	2,745
	38.0	7.765	8.625	0.430	2,928	6,750	3,375
	43.0	7.625	8.625	0.500	3,638	8,380	4,190
9⅝	33.0	9.500	10.000	0.250	780	1,800	900
10	40.0	10.000	10.750	0.375	1,638	3,770	1,885
	48.0	9.850	10.750	0.450	2,234	5,150	2,575
	54.0	9.750	10.750	0.500	2,643	6,090	3,045
11⅝	40.0	11.437	12.000	0.281	641	1,475	737
12½	40.0	12.500	13.000	0.250	402	927	463
	45.0	12.360	13.000	0.320	745	1,717	858
	50.0	12.250	13.000	0.375	1,109	2,560	1,280
13½	50.0	13.250	14.000	0.375	936	2,160	1,080
15½	51.3	15.416	16.000	0.292	314	724	362

CASING RECORDS AND DRILLING TIME.

Midway—Sunset—McKittrick.

Standard Tools.

Depth	Number of wells	Depth			18-inch				15½-inch				12½-inch				10-inch			
		Av.	Max.	Min.	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.
800 to 1,500 feet	70	1,120	1,499	510	-------	-------	-------	-------	-------	-------	-------	-------	22	776	1,357	390	50	916	1,379	400
1,500 to 2,000 feet	35	1,736	2,000	1,500	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	24	1,415	1,790	893
2,000 to 3,000 feet	48	2,430	2,990	2,012	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	22	1,720	2,118	1,028
3,000 +	18	3,300	4,691	3,046	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	4	2,720	3,075	2,538

Rotary Tools.

	7	982	1,071	880	-------	-------	-------	-------	-------	-------	-------	-------	1	656	-------	-------	6	530	712	470
	25	2,930	3,389	2,570	4	617	751	440	6	608	894	311	8	475	1,025	280	6	2,203	2,400	1,951

CASING RECORDS AND DRILLING TIME—Continued.

Midway—Sunset McKittrick.

Standard Tools.

Depth	Number of wells	Depth			8¼-inch				6-inch				4-inch				Drilling rate, feet per day		
		Av.	Max.	Min.	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.	Av.	Max.	Min.
800 to 1,500 feet	70	1,120	1,499	510	34	1,098	1,498	366	-------	-------	-------	-------	-------	-------	-------	-------	30.5	57.5	6.6
1,500 to 2,000 feet	35	1,736	2,000	1,500	25	1,670	1,957	1,072	9	1,780	1,989	1,442	-------	-------	-------	-------	29.0	63.5	5.4
2,000 to 3,000 feet	48	2,430	2,990	2,012	19	2,180	2,830	1,863	17	2,440	2,914	2,010	6	2,480	2,540	2,264	16.5	53.4	5.7
3,000+	18	3,300	4,691	3,046	9	2,780	3,587	2,427	13	2,460	4,075	2,188	-------	-------	-------	-------	13.3	30.0	7.6

Rotary Tools.

					1	1,065	-------	-------	6	789	1,071	337	-------	-------	-------	-------	66.4	105.0	39.0
					23	2,690	3,031	1,965	22	2,830	3,387	2,020	-------	-------	-------	-------	24.5	46.8	7.9

CASING AND LABOR COST.

Standard Tools.

Summary of Foregoing Casing Record.

Wells	800 ft. to 1,500 ft. 70 (av. 1,120 ft.)		1,500 ft. to 2,000 ft. 35 (av. 1,736 ft.)		2,000 ft. to 3,000 ft. 48 (av. 2,430 ft.)		3,000 ft. + 18 (av. 3,300 ft.)		Average unit prices (casing per foot; labor per day)
Feet drilled	78,400	----------	60,760	----------	116,640	----------	59,400		
Feet per day	30.5	----------	29.0	----------	16.5	----------	13.3		
Casing	Feet	Cost	Feet	Cost	Feet	Cost	Feet	Cost	
12½-inch	17,072	$29,876	--------	----------	--------	----------	--------	----------	$1.75
10-inch	45,800	79,234	33,960	$58,751	37,840	$65,463	10,880	$18,822	1.73
8¼-inch	37,332	42,932	41,750	48,013	41,420	47,633	25,020	28,773	1.15
6¼-inch	--------	----------	16,020	16,821	41,480	43,554	31,980	33,579	1.05
4½-inch	--------	----------	--------	----------	14,880	9,226	--------	----------	.62
Casing total	--------	$152,042	--------	$123,585	--------	$165,876	--------	$81,174	
Casing per foot	--------	1.94	--------	2.03	--------	1.43	--------	1.37	
Labor total	Days 2,570	$59,110	Days 2,095	$48,185	Days 7,069	$162,587	Days 4,466	$102,718	$23.00
Labor per foot	--------	.75	--------	.79	--------	1.39	--------	1.73	
Total casing and labor	--------	211,152	--------	171,770	--------	328,463	--------	183,892	
Casing and labor per foot	--------	2.69	--------	2.82	--------	2.82	--------	3.10	

Rotary Tools.

Wells	1,000 ft. 7 (av. 982 ft.)		3,000 ft. 25 (av. 2,930 ft.)		Average unit prices (casing per foot; labor per day)
Feet drilled	6,874	----------	73,250		
Feet per day	66.4	----------	24.5		
	Feet	Cost	Feet	Cost	
18-inch casing	--------	----------	2,468	$6,590	$2.67
15½-inch casing	--------	----------	3,648	8,792	2.41
12½-inch casing	656	$1,159	3,800	6,650	1.75
10-inch casing	3,180	5,501	13,218	22,867	1.73
8¼-inch casing	1,065	1,810	75,088	87,102	1.15
6¼-inch casing	4,734	4,971	62,260	65,373	1.05
Casing total	--------	$13,441	--------	$197,374	
Casing per foot	--------	1.96	--------	2.69	
Labor total	Days 103.5	$4,761	Days 2,989.8	$137,530	
Labor per foot	--------	.69	--------	1.87	$46.00
Total casing and labor	--------	18,202	--------	334,904	
Casing and labor per foot	--------	2.65	--------	4.56	

Cost of drilling with Rotary tools in the Midway Field is shown by the following average account, on a well 3,277 feet deep, with a 10-inch "water string" and 6⅝-inch "oil string" (of casing):

Derrick and rig.	
Lumber (106 foot derrick)	$1,067 76
Nails	28 04
Bolts	24 80
Corrugated galvanized iron	124 37
Miscellaneous	2 10
Rig irons	580 14
Overhead expense on material	73 90
Labor (building)	232 50
Overhead (labor)	50 56
Shop work	145 03
Teaming (rig, boilers, engines)	453 98
Engines and boilers.	
Engine	290 07
Boilers (3)	1,305 00
Foundations and settings	54 90
Pipe and fittings	425 48
Labor (erecting)	150 00
Belts	96 66
Tanks and flume	196 46
Lumber (foundation and flume framing)	16 22
Sump hole	100 00
Drilling.	
Labor (drillers, toolies, circulator)	7,002 51
Labor extra (rig up, pulling casing)	487 03
Drill tools	523 96
Drill stems and joints	3,760 00
Depreciation on tools and machinery, including stem bits, etc.	2,909 08
Cordage	659 84
Casing, 10 inch (2,850 feet)	5,007 86
Casing, 6⅝ inch (3,277 feet)	2,442 31
Fuel (gas)	106 00
Water	730 09
Electricity	58 74
Repairs (engine, rig and boiler)	476 58
Oil, waste and packing	100 30
Sundries:	
Overhead (material)	433 02
Overhead (superintendence)	1,690 00
Shop work (tools and machinery)	328 39
Cement	15 75
Ice	43 19
Hose (Rotary, etc.)	90 98
Miscellaneous	51 30
Teaming (while drilling)	1,846 54
Fishing.	
Rental and loss of tools	14 25
Labor (fishing)	245 00
Cementing.	
Finishing (well flowed).	
Tubing, 3,000 feet 2½ inch	729 00
Sucker rods (3,000 feet), pump, etc.	266 70
Total	$35,436 39
Total cost per foot	$10 86
Casing cost per foot	2 28
Total labor cost per foot	2 48
Drilling labor cost per foot	2 14
Working time	125 days
Rate per day	26.2 feet

The cost of drilling with Standard tools in the Midway Field is indicated by the following itemized account of a shallow and cheap well (depth 930 feet):

Derrick and rig.	
Lumber for 84 foot rig complete (contract price)	$683 00
Nails, 2 kegs 20d.	7 20
Nails, 2 kegs 10d.	7 30

Derrick and rig—Continued.		
Nails, 2 kegs 30d.		$ 6 82
Nails, 1 keg 60d.		3 42
Miscellaneous bolts and washers		21 60
Rig irons and bolts (1 set 6 inch Ideal rig irons and bolts complete)		593 80
Labor (building) contract		225 00
Shop work, wiring, etc.		
Material	$21 40	
Labor	21 00	
		42 40
Engines and boilers.		
Engine, one 10½ x 12 Ajax		325 00
Boilers, none.—(Got steam from boiler plant.)		
Pipe and fittings, miscellaneous material		84 60
Labor, 4 men 1 day at $3		12 00
Erecting and cementing boiler (not cemented).		
Belts, one 12″ x 90′ Diamond		73 00
Tanks, one 100 barrel galvanized iron tank		84 00
Sump hole.		
Two 4-horse teams 5 days at $8		80 00
Two men 5 days at $3		30 00
Drilling.		
Labor (drillers, toolies and circulator for men).		
2 drillers 33 days at $7		462 00
2 toolies 33 days at $4.50		297 00
Extra labor (rigging up, pulling casing).		
Drill tools (bits, stems, jars, rope, sockets, boilers, pipe tongs, spiders, slips, anvils, cranes, bit, gauges and rental of tools). Drilling tools not directly charged to wells (25 cents per foot, which amounts to $232 on this well)		232 00
Cordage (sand, drilling and casing lines, manila cables, bull ropes, logging, etc.).		
Two 2½″ x 90′ bull ropes		35 60
One 1″ x 2,500′ drilling line (used on 2 or 3 wells)		400 93
One ⅞″ x 900′ casing line (used on 2 or 3 wells)		94 71
One 9-16″ x 2,000′ sand line		87 77
Casing (cost or value of all left in well, including that drilled by or drilled out).		
600 feet 12½″ 40-pound Wheeling casing		918 00
930 feet 10″ 40-pound X. X. Marks casing		1,339 20
One 12½″ Baker casing shoe		65 00
One 10″ common casing shoe		21 57
General tools (hammers, sledges, wrenches, cutters, pipe threading tools, etc.).		
Miscellaneous set of small tools		50 00
Fuel and water.		
1,300 barrels water		357 50
Fuel charged to boiler plant.		
Repairs (engine, rig or boiler)		10 80
Oil and waste		2 60
Packing		------
Sundries.		
Teaming (while drilling), one 2-horse team 3 days		22 50
Finishing.		
Labor (bailing, tubing, putting on beam).		
1 man 2 days at $4.50		9 00
3 men 2 days at $3.50		21 00
String of tubing.		
850′ 3″ tubing		212 50
Sucker rods and pump.		
850′ ¾″ sucker rods		76 50
One 3″ x 64′ Axelson pump		37 50
Total		$7,035 82
Total cost per foot		$7 56
Casing cost per foot		2 52
Total labor cost per foot		1 16
Drilling labor cost per foot		82
Working time		35 days
Rate per day		26.6 feet

PUMPING OR PRODUCTION COST.

Comparison of pumping cost in the Midway Field by electricity and by gas engines is shown by the following monthly figures on two groups of wells under the same management:

Electricity.		Gas.	
12 wells, oil 17° B.		13 wells, oil 17° B.	
Depth, 1,360 feet.		Depth, 1,360 feet.	

Equipment (Motive Power).

Electric motors (installed)	$11,247 86	Gas engines, 9	$11,039 04
Gas lines	540 42	Steam engines, 2	1,000 00
Power lines	2,409 97	Gas lines	3,603 81
		Steam lines	321 82
	$14,198 25		
			$15,964 67
Per well	1,183 19	Per well	1,228 05

Operation.

Labor	$308 24	Labor	$438 79
Electricity	354 52	Water (electricity and gas)	165 80
Miscellaneous	38 72	Miscellaneous	57 29
Total operation	$701 48	Total operation	$661 88
Per well day	1 95	Per well day	1 69

Repairs (Wells).

Labor	$182 15	Labor	$342 54
Material	58 16	Material	283 78
Total repairs	$240 31	Total repairs	$326 32
Repairs per day	0 667	Repairs per day	1 74
Total operation and repairs		Total operation and repairs	$1,288 20
Per well day	2 62	Per well day	3 30

Operation costs of three groups (A, B, and C) of Midway wells, and total operating cost of property embracing them. Gravity of oil 15° B., depth 800 feet to 1,500 feet. Overhead expenses not included.

Total Operations, Repairs and Upkeep.

	November	December	January	February	March	April
Total labor	$14,474	$14,784	$14,443	$12,001	$11,792	$10,748
Total material	17,748	18,182	22,534	11,035	12,232	13,807
Total teaming	1,964	2,040	2,064	1,631	1,417	1,470
Total machine shop	920	866	656	707	408	625
Total	$35,106	$35,872	$39,697	$25,374	$25,849	$26,650
Total, less material returned	$29,179	$30,254	$35,084	$21,248	$21,589	$24,102
Per barrel	$.161	$.157	$.184	$.122	$.118	$.143
*Water, gas and oil (produced on the property)	$7.363	$8.384	$7.664	$7.071	$6.160	
Total of all operations	$42.469	$44.256	$47.361	$32.445	$32.009	
Per barrel	$.235	$.229	$.243	$.186	$.175	

Boiler water not treated. No drilling going on.
*Oil, $5,114.25 at 85.

Group A.

Pumping from wells to tanks (including cleaning oil).

	Number of wells	Barrels per well day	Labor	Material	Teaming	Total	Per barrel	Per well day
November	26	55.17	$2,946	$2,187	$337	$5,470	$.127	$7.01
December	26	66.25	2,199	2,870	334	5,403	.101	6.59
January	26	71.26	2,446	1,478	254	4,178	.072	5.18
February	26	63.62	2,032	1,540	250	3,823	.079	5.07
March	26	58.32	1,838	1,516	225	3,579	.076	4.43
April	26	63.00	1,927	1,179	208	3,315	.068	4.25

Material—Oil, waste, packing.
Operations—Repairs to plant and pumps, office.
Teaming—2 horses and man at $6 (lubricating oil and field tools).
Two boiler plants—gas purchased at $1,000 per month.

2 firemen at $3.96.	4 oilers at $3.47.
2 firemen at $4.29.	1 foreman at $4.00.
8 pumpers at $3.47.	2 roustabouts at $3.47.

Group B.

	Number of wells	Barrels per well day	Labor	Material	Teaming	Total	Per barrel	Per well day
November	47	73.66	$3,447	$3,547	$245	$7,239	$.069	$5.12
December	47	73.44	3,234	3,261	221	6,716	.064	4.81
January	48	66.39	3,276	3,987	229	7,492	.078	5.03
February	48	67.27	3,151	3,295	259	6,705	.071	4.80
March	54	60.16	3,168	3,145	264	6,577	.065	3.93
April	54	53.63	2,870	2,682	219	5,771	.067	3.56

Four boiler plants—Gas at $2,500 per month.

2 firemen at $4.00.	7 oilers.
2 firemen at $3.96.	2 foremen.
4 firemen at $3.47.	8 roustabouts.
8 pumpers.	

Group C.

	Number of wells	Barrels per well day	Labor	Material	Teaming	Total	Per barrel	Per well day
November	25	44.42	$1,496	$499	$103	$2,098	$.062	$2.79
December	26	43.25	1,613	472	157	2,242	.064	2.78
January	27	40.64	1,758	1,097	169	3,024	.087	3.61
February	27	41.56	1,482	876	123	2,481	.076	3.16
March	27	41.57	1,613	913	129	2,655	.076	3.17
April	27	39.58	1,547	902	142	2,591	.081	3.19

Two boiler plants—gas at $1,075 per month.

4 firemen at $3.47.	1 foreman.
4 pumpers.	4 roustabouts.
2 oilers.	

Operating and repair cost of group of 39 Midway wells, one month (31 days), with 18 gas engines and 21 steam engines, depth of pump, average 1,435 feet (655 feet to 2,878 feet), gravity of oil 18.2° B., 0.3 per cent sand, pumps nearly all 3 inches, oil 252,636 barrels (209.5 barrels per well day).

Operation	Total	Per well day
Pumping labor	$840 35	$.697
Pulling labor	657 73	.542
Cleaning labor	81 00	.067
Material*	913 18	.755
	$2,492 26	$2.061
Repairs.		
Labor	$575 59	$.476
Material	1,178 75	.974
	$1,754 34	$1.450
Total	$4,246 60	$3.511
Per barrel		.0168

*Including pro rata of operation and upkeep of central steam plant.
Pumps worn out, 11 at $24.00.
Rods worn out, 32 at $3.57.

Operating cost of a group of four North Midway wells producing about 60,000 barrels 16° B. oil from a depth of 765 feet, is partly shown by the following figures covering six months:

Labor (pumping)	$1,260 00	
Gas	240 00	
Water	480 00	
Electricity	960 00	
Oil, waste, packing, etc.	90 00	
Labor (cleaning wells)	300 00	Repairs, $0.687 per well day.
Teaming	50 00	
Pumps and rods	150 00	
Total	$3,530 00	
Per well day	$4 83	
Per barrel	$0 059	
Barrels per well day	82	

Operation cost of a group of 15 and 16 Midway wells for ten months, depth 800 feet to 1,000 feet, gravity of oil 14° B.

1911 and 1912.

	December	January	February	March	April	May	June	July	August	September
Foreman	$445	$137	$174	$171	$165	$171	$189	$182	$149	$150
Labor, miscellaneous	78	63	63	39	52	121	63	118	37	109
Labor, pumping	625	636	432	468	556	408	428	415	437	630
Oil, waste, packing	37	90	28	33	28	50	53	84	63	67
Miscellaneous	-------	1	-------	-------	2	3	16	-------	-------	-------
Cleaning and pulling	437	389	246	317	594	312	274	403	334	344
Fuel oil (at 50 cents)	622	415	400	700	746	647	541	365	464	440
Teaming	93	109	111	130	167	176	177	173	170	179
Repairs:										
Pipe lines	30	70	71	92	53	55	14	37	19	30
Pumps	54	46	48	4	7	-------	83	1	-------	30
Boilers and engines	44	372	31	54	8	62	176	106	151	317
Buildings	1	40	7	-------	-------	2	-------	7	53	6
Tanks	-------	-------	-------	3	-------	9	-------	-------	-------	-------
Tools	1	-------	-------	-------	-------	6	2	46	16	16
Wells	82	97	51	397	285	308	631	399	345	93
Roads	-------	-------	-------	8	-------	-------	-------	-------	-------	-------
Sumps	27	-------	-------	-------	13	13	2	1	15	7
Wagons	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
General at wells, lights	81	23	21	16	36	53	41	35	40	42
Boarding house operating, electricity	407	466	388	434	465	383	393	466	471	446
Water	467	259	200	200	200	-------	-------	-------	-------	-------
Install compressor	-------	-------	-------	62	43	200	200	200	306	301
Total expense	$3,531	$3,213	$2,271	$3,128	$3,420	$2,929	$3,283	$3,038	$3,070	$3,207
Total barrels	29,008	32,178	19,780	22,957	21,091	25,756	25,551	28,956	27,893	25,278
Number of wells	15	15	15	15	15	15	15	15	16	16
Barrels per well day	62.4	69.0	45.5	49.3	46.9	55.4	56.7	62.2	56.2	53.0
Cost per well day	$7.49	$6.90	$5.22	$6.73	$7.60	$6.30	$7.29	$6.53	$6.19	$6.68
Cost per barrel	$.122	$.100	$.115	$.136	$.162	$.114	$.128	$.105	$.110	$.127

ELECTRIC POWER.

Electric power for pumping oil wells is supplied by the San Joaquin Light and Power Company at the following rates:

1 to 19 motors, inclusive	1.5 cents per kilowatt hour
20 and under 30 motors	1.4 cents per kilowatt hour
30 and under 40 motors	1.3 cents per kilowatt hour
40 and under 61 motors	1.2 cents per kilowatt hour
61 motors and over	1.0 cents per kilowatt hour

The number of kilowatt hours to be paid for shall be determined by measurements taken with an integrating watt-hour meter installed on the secondary side of step-down transformers by the power company and kept in adjustment by it.

Early in 1914 their reports show thirty-one companies, with the following number of wells using electric power in this field, and others near by:

Midway	329
Maricopa	2
McKittrick	23
Belridge	17
Lost Hills	13
Temblor	13
Total	397

The power company builds lines to the boundary of the property. Additional cost, paid by the operator, is indicated by the following figures showing actual expenditure on one property:

Building and secondary line to serve 6 motors	$480 21
Wiring and installing 6 motors	495 48
Each motor (10 to 30 Delta Star)	510 00
Each countershaft	90 00
3 transformers (20 kilowatts), capacity 12 wells	600 00

Power required to pump various oil wells is shown by the following table. Doubtless the variation in gravity and viscosity of oils partly accounts for the rather wide range in power consumed:

February, 1913.

Total power consumed, kilowatt hours	Number of wells	Average kilowatt hours per well per day	Total production, barrels	Kilowatt hours per barrel	Average barrels daily produced per well	Average depth of well	Kilowatt hours per barrel per 100 feet
36,575	12	98.3	85,384	0.429	229.5	958	.0448
35,375	12	95.0	64,656	0.547	173.8	1,339	.0409
35,230	11	103.3	47,964	0.735	140.7	1,953	.0376
8,560	5	55.2	2,090	4.096	13.5	1,384	.2955
5,000	2	80.6	3,050	1.639	49.2	2,474	.0663
6,340	2	102.3	1,085	5.843	17.5	2,205	.0844
17,670	5	114.0	12,845	1.376	82.9	2,665	.0516
2,995	1	96.6	1,860	1.610	60.0	2,692	.0598
5,250	3	56.5	8,607	0.610	92.5	2,901	.0210
3,550	2	57.3	1,175	3.021	19.0	1,517	.1992
3,470	2	56.0	4,920	0.705	79.5	2,195	.0322
14,010	9	50.2	2,869	4.883	10.3	1,029	.4758
2,200	2	35.5	1,152	1.910	18.6	1,691	.1130
5,330	2	86.0	4,028	1.323	65.0	2,268	.5840
4,975	1	160.5	1,460	3.408	47.1	2,066	.1650
3,825	1	123.4	1,741	2.197	56.2	3,110	.0706
1,720	2	27.7	870	1.977	14.0	1,706	.1159
10,290	3	109.3	2,227	4.580	23.9	2,775	.1650
8,970	3	96.5	12,107	0.741	130.2	2,621	.0272
9,975	3	107.3	17,350	0.575	186.6	1,103	.0521
18,000	8	72.6	8,898	2.023	35.9	1,030	.1965
239,310	91	84.8	286,338	0.835	101.5	1,659	.0504

The General Electric Company of Schenectady, N. Y., has published several papers dealing with electric equipment and costs at oil wells.

STEAM POWER.

Operation of steam power plant (referred to in account of group of 39 wells), pumping 8 wells (capacity 18 wells), four 100 horsepower boilers, one month (31 days).

Material—		
Miscellaneous	$23 87	
Oil (279 barrels)	280 66	
Water (2,914 barrels)	72 85	
		$377 38
Labor—		
Firing	$213 71	
Repairs	12 35	
Cleaning at $3.50 per day	31 30	
Sundry	12 21	
		269 57
Total		$646 95

Comparison of pumping cost by steam and electricity on a group of 12 Midway wells for periods of five months, 1911:

Oil	13° B.
Depth	600 feet to 1,200 feet
Number of wells	12
Strokes per minute	20

	Per well per day	
	Steam	Electricity
Labor, pumping	$1.15	$1.18
Operating electric equipment		1.07
Fuel oil at 50 cents	1.47	.42
Water at 5 cents per barrel	1.95	.95
Repairs, boilers and engines	.25	.06
Oil, waste, packing	.27	.17
Totals	$5.09	$3.85

Counter balance on beam saved 10 per cent to 20 per cent cost of power.

Cost of installation:

Motors, eleven 15 to 5 horsepower, one 20 to 6⅔ horsepower	$6,670 00
Three 25 kilowatt transformers	3,500 00

Installation (estimate).

GAS POWER.

Cost of an engine and its installation for pumping a well is shown as follows, by figures of a very large operator. (Same property as accounts for 39 wells.)

	Labor	Material
Cement foundation and floor	$94 83	$100 19
Engine (30 horsepower)*		850 00
Engine installing	90 74	
Engine fittings		47 78
House (16 x 16 x 8) galvanized iron	26 11	89 01
Tank (7′ 10″ x 9″) corrugated iron	6 70	65 00
Teaming	55 50	
	$273 88	$1,151 98
Total $1,425 86		

---

*A 25 horsepower costs from $100 to $120 less.

Operating cost of engines by the same operator were as follows for one month with eight 30 horsepower engines and eight 25 horsepower engines.

Gas taken from the operator's wells by a vacuum pump, a half a mile of 6-inch pipe constituting the storage.

Labor for operation is not included, being charged to the wells, one pumper attending ten wells and their engines.

	Price	8 engines, 30 horsepower		8 engines, 25 horsepower	
		Amount	Total	Amount	Total
Calumet gas engine oil	$.43	60 gal.	$25.80	55 gal.	$23.65
Atlantic Red oil	.20	60 gal.	12.00	35 gal.	7.00
Artic cup grease	.06	22 lbs.	1.32	----------	--------
Distillate (wash)	.07	10 gal.	.70	10 gal.	.70
Tallow	----------	----------	----------	----------	--------
Waste	.10	16 lbs.	1.60	5 lbs.	.50
Water	.027	111 bbl.	3.04	120 bbl.	3.28
Rosin	----------	5 lbs.	.65	----------	--------
(Credit) waste oil*	.12	28 gal.	$3.36	19 gal.	$2.28
Repairs and renewals.					
Labor, per month	130.00	----------	22.36	----------	4.10
Belt lace	----------	5 ft.	.06	----------	--------
Sheet asbestos	----------	2½ lbs.	----------	----------	--------
Mill brooms	.18	2	.36	3	.54
Hot tubes	2.00	1	2.00	----------	7.50
Total (less gas)	----------	----------	$66.53	----------	$44.99
Per day (less gas)	----------	----------	2.217	----------	1.50
Gas for engines (at 5 cents per M), 864,975 cu. ft.	----------	----------	43.11	772,000	34.56
Gas for hot tubes, 45,525 cu. ft.	----------	----------	2.04	48,000	2.48
Total (plus gas at 5 cents per M)	----------	----------	$111.68	----------	$82.03
Per day (plus gas)	----------	----------	3.733	----------	--------
Time off account engine, hours	----------	----------	9	----------	--------
Time off, other causes	----------	----------	521	----------	142
Gas, 7,000 cu. ft. to 1 bbl. oil at 35 cents.					

NATURAL GAS.

The principal gas producing area of California is located in the Midway Field, along the crest of the Buena Vista Hills anticline. It extends from about Section 22, T. 31 S., R. 23 E., to Section 14, T. 32 S., R. 24 E. The strip averages possibly one and one half miles wide in its northwestern portion to two and one half miles wide towards the southeastern end, or an area of probably not more than 11,000 acres. The gas is usually found in fine grained blue sandy shale.

The highest rock pressures seem to prevail in the Eastern Hills, in T. 32 S., R. 24 E., in which the Honolulu Consolidated Oil Company wells are located. Wells in this locality have shown closed-in pressures on the gauge as high as 1,260 pounds per square inch, with open flow measurements exceeding 50,000,000 cubic feet per day. Gas at these high pressures seems to come from a depth of not less than 2,100 feet, but gas measures of large volume with lighter pressures have been encountered at various depths from 800 to 1,600 feet. One well in particular on the northeast quarter of Section 8, 32–24, blew out at a depth of not less than 900 feet, and immediately caught fire from the forge inside the derrick. The well was being drilled by cable tools and the pressure was sufficient to blow the tools and some of the 12½ inch casing out of the hole. The fire lasted some twenty hours, when the well closed up suddenly by being choked with shale and the flame was consequently extinguished. An examination showed a crater some thirty feet in diameter and thirty to forty feet deep, where the derrick had stood and the string of 12 inch tools lay crossways over the hole.

In the early development, gas blow-outs were frequent, resulting often in serious fires, some of which lasted for weeks before finally being extinguished. These blow-outs were principally due to the excessive pressures bursting the fittings used to close in the wells, but these experiences led up to the design and adoption of a special type of blow-out preventor and fittings, but even with this type of fitting the drilling in such measures is still very hazardous and blow-outs often occur. Gas wells vary considerably in pressure and volume, some wells having a high rock pressure and small volume, while others have large volume and low rock pressure, and there are no means of telling from surface indications what the results of drilling are likely to be, and a well able to deliver 5,000,000 cubic feet daily against a line pressure of 400 pounds per square inch, is considered an exceptionally fine well.

The accompanying diagram (Fig. 31) shows the decrease of production and pressure as the wells continue to flow:

The cost of drilling wells in this territory varies from $30,000 to $100,000 per well, and some of the most productive wells have cost the least to drill.

Composition of the gas is shown by the following results of analyses:

Analyses of Gas from Various Wells.

	S. O. Co. No. 1, Sec. 22			S. O. Co. No. 5, Sec. 26. 1910	Honolulu No. 1, Sec. 6. 1910	S. O. Co. No. 1, Sec. 14. 1910	Honolulu No. 1, Sec. 24. 1911	S. O. Co. No. 2, Sec. 22. 1911	S. O. Co. No. 2, Sec. 26. 1911
	1910, per cent	1911, per cent	1912, per cent						
Carbon dioxide CO_2	.10	.30	.30	3.60	7.00	.25	3.2	.70	3.20
Ethylene (illuminants) C_2H_4	.60	.05	.04	.60	.20	1.95	.80	.10	.40
Oxygen O_2	.50	.05	.06	.80	.30	.80	.30	.30	.30
Methane CH_4	94.30	96.44	96.26	90.90	87.55	96.00	92.00	94.30	92.80
Ethane C_2H_6				1.35					
Hydrogen H_2	1.14				1.20	.10	.20		
Nitrogen N_2	3.36	3.16	3.34	2.75	3.75	.90	.30	4.60	3.30
Other hydrocarbons							3.20		
Specific gravity (air = 1)	.5747	.5626	.5568	.5867	.6459	.5865	.605	.5656	.6271
British thermal units per cu. ft. at 32° F. and 29.92 gross	.1103	.1092		.1087	.966	.1289	.1123	.1030	.1070
British thermal units per cu. ft. at 32° F. and 29.92 net	.1018	.1016		.997	.913	.1219	.1053	.970	.999
British thermal units per cu. ft. at 60° F. and 29.92 gross			.1025						
British thermal units per cu. ft. at 60° F. and 29.92 net	.966	.963	.954	.942	.961	.1155	.998	.920	.947

Analyses of Gas from Various Wells—Continued.

	S. O. Co. No. 4, Sec. 26. 1911	S. O. Co. No. 5, Sec. 26. 1911	S. O. Co. Derby No. 1. 1912	S. O. Co. Derby No. 2. 1912	S. O. Co. No. 3, Sec. 26. 1912	S. O. Co. No. 6, Sec. 26. 1912	S. O. Co. McKee No. 7. 1912	S. O. Co. Cal. Nat. Gas well, No. 9. Sec. 36. 1912	S. O. Co. No. 5. Sec. 22. 1912
Carbon dioxide CO_2	3.70	3.65	7.30	7.50	4.10	3.50	11.70	3.40	1.55
Ethylene (illuminants) C_2H_4	.20	.10	.95	.20	.50	.45	1.60	.10	.35
Oxygen O_2	.20	.15	.10	.10	.30	.15	.10	.05	.65
Methane CH_4	95.09	91.38	81.41	90.00	86.74	93.43	82.75	90.51	96.37
Ethane C_2H_6	----------	----------	1.65	1.22	6.27	1.15	2.41	----------	----------
Hydrogen H_2	----------	----------	----------	----------	----------	----------	----------	----------	----------
Nitrogen N_2	.81	1.57	----------	.98	2.09	1.32	1.44	3.63	.75
Other hydrocarbons	----------	3.15	----------	----------	----------	----------	----------	2.26	.33
Specific gravity (air = 1)	.5682	.6137	.6874	.6112	.6301	.6021	.6761	.6025	.5906
British thermal units per cu. ft. at 32° F. and 29.92 gross	.1092	.1069	----------	----------	----------	----------	----------	.1014	.1044
British thermal units per cu. ft. at 32° F. and 29.92 net	.1017	.994	----------	----------	----------	----------	----------	----------	----------
British thermal units per cu. ft. at 60° F. and 29.92 gross	----------	----------	.1084	.1000	.1050	.1098	.1021	.962	.990
British thermal units per cu. ft. at 60° F. and 29.92 net	.964	.942	.995	.921	.981	.1018	.947	.887	.915

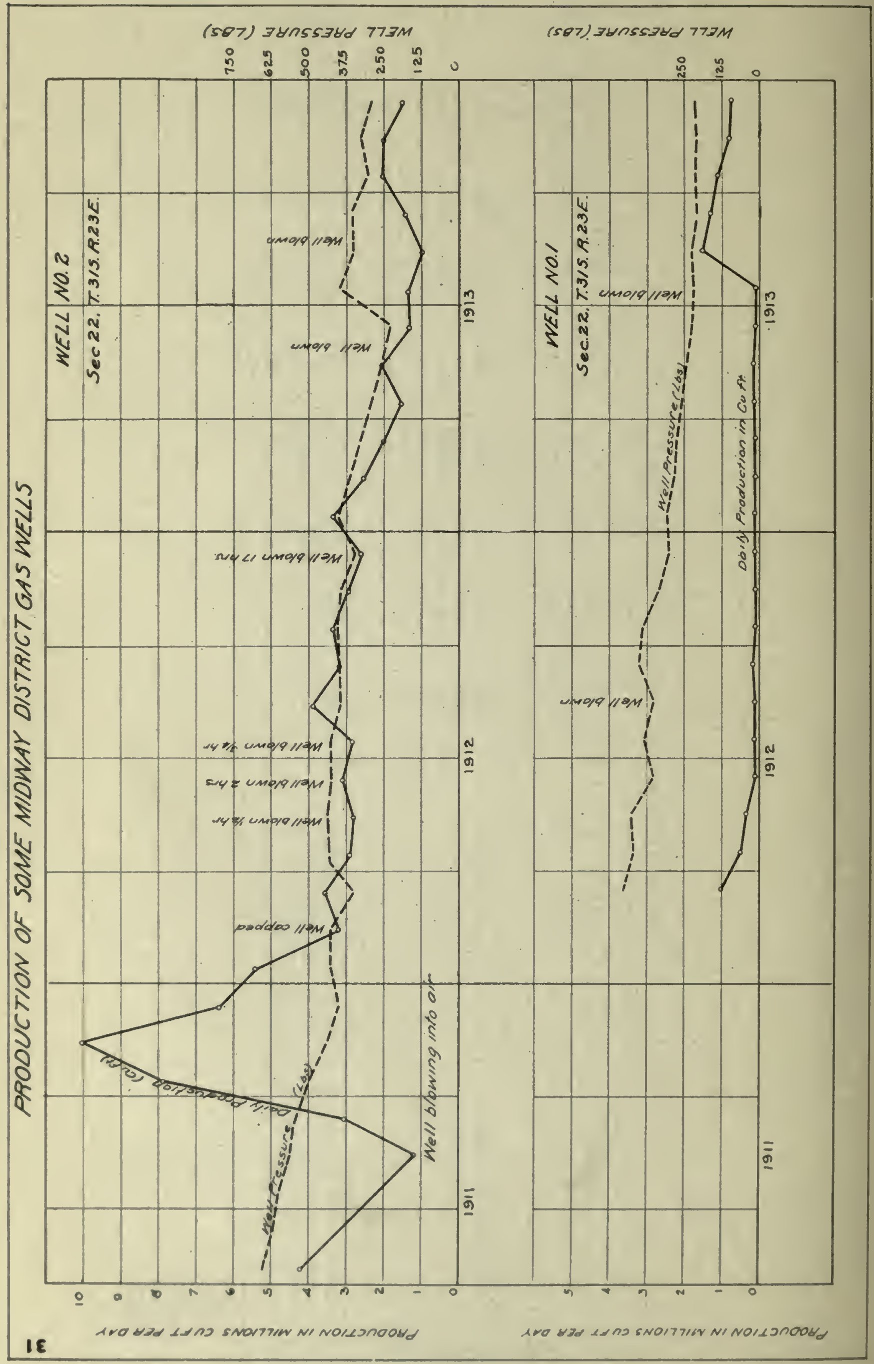
PRODUCTION OF SOME MIDWAY DISTRICT GAS WELLS
WELL NO.2
Sec 22. T.31S. R.23E.
WELL PRESSURE (LBS)
750
625
500
375
250
125
0
PRODUCTION IN MILLIONS CU FT PER DAY
10
9
8
7
6
5
4
3
2
1
0
Well blown
Well blown
Well blown 17 hrs.
Well blown 1/4 hr
Well blown 2 hrs
Well blown 1/2 hr
Well capped
Daily Production (cu.ft.)
Well Pressure (Lbs)
Well blowing into air
1911
1912
1913
WELL NO.1
Sec.22. T.31S. R.23E.
WELL PRESSURE (LBS)
250
125
0
PRODUCTION IN MILLIONS CU FT PER DAY
5
4
3
2
1
0
Well blown
Well blown
Well Pressure (Lbs)
Daily Production in Cu ft
1911
1912
1913
31

Fig. 31.

The gas produced in the Midway Field is handled by two companies, viz: California Natural Gas Company and the Southern California Gas Company.

The California Natural Gas Company operates the gas wells of the Standard Oil Company, and delivers natural gas wholesale to the towns of Bakersfield, Fellows, Taft and Maricopa, in which towns local retail companies distribute to the domestic consumers. The California Natural Gas Company also delivers natural gas direct to industrial consumers throughout the Midway Field for well drilling operations, pumping plants and power plants.

The Southern California Gas Company is affiliated with the Midway Gas Company and acts as its lessee and its agent in operating the 12 inch gas transmission line from the Midway field to Los Angeles. These companies have contracts with the Southern Pacific Land Company, Kern Trading and Oil Company and Associated Oil Company by which they have the exclusive rights to drill for and produce gas from the lands of the last mentioned companies in the Buena Vista Hills.

The Northern Exploration Company is a subsidiary of the Midway Gas Company and its function is to drill gas wells upon the lands above mentioned and produce and deliver gas to the line of the Midway Gas Company.

The Southern California Gas Company and the Midway Gas Company entered into contracts with the Honolulu Consolidated Oil Company whereby the former companies secured the rights to all gas produced by the latter company in excess of the amount needed to supply the proportion required by the California Natural Gas Company and for the Honolulu Consolidated Oil Company's own requirements.

The main transmission line from the Midway Field to Los Angeles has a capacity of about 23,000,000 cubic feet per day, and it is expected that the consumption of Los Angeles and its vicinity will reach this figure during the winter of 1914–15. Of this amount it is the intention to take from wells on the lands of the Southern Pacific Company and Associated Oil Company about 10,000,000 cubic feet daily, and the same amount from the Honolulu Consolidated Oil Company. The balance will consist of casing head and low pressure gas, which it is intended to pass through the Midway Gas Company's new compressor station and deliver into the line at the pressure necessary for passage.

To date the gas has been metered into the line through standard make proportional meters, which gauge a certain percentage of the flow through a tally recording device.

Paper charts covering each day's delivery revolve with clock-work mechanism and red ink lines are inscribed on each showing the pressure per square inch at any part of the day and the volume passing through.

A simple computation from the results of such charts gives the total number of feet passing through the meters at a calculated pressure of 4 ounces above atmosphere, on which basis the gas is bought and sold.

The above type of meter is liable to considerable error, either fast or slow, should the tally mechanism get out of order through the presence of moisture, sand, or dust in the gas.

A new type, called the orifice meter, is now being tried out with a view of making a complete installation, and inasmuch as in this type the entire volume of gas passes through the ''orifice,'' it is expected that errors of measurement will be minimized. The orifice meters are equipped with recording devices and revolving charts and keep a continuous record of the pressures on each side of the ''orifice'' and simple calculations similar to those used to apply to Pitot tube readings give the results in volume of gas passed.

For the passage of 23,000,000 cubic feet through the line to Los Angeles, 107 miles long, an intake pressure of approximately 400 pounds per square inch will be required to maintain a pressure of 50 pounds per square inch at the Los Angeles end of the line. The strong probabilities of the well pressures dropping at some time in the future below the 400 pounds, required from the maximum output, and the presence of so much casing head and low pressure gas in the field, determined the Midway Gas Company to construct and equip a compressor station of the full capacity of the line, so that the line pressure could be maintained and the casing head and low pressure gas that would otherwise be wasted could be utilized. The saving of low pressure gas of course conserves the supply of high pressure gas and is a notable instance where operators are providing for the future by conserving the natural resources. This station is now completed and in operation on a portion of the gas delivery, the discharge from the compressors into the line being made at the same pressure as the high pressure gas direct from the wells is being delivered. The compressors are driven by gas engines, utilizing natural gas supply as fuel. The compressing of such large quantities of low pressure and casing head gas will naturally result in obtaining large quantities of gasoline and distillate, and a ready market for this product will be found in the Midway Field for the operation of automobiles, motor trucks and gas engines.

All the gas wells are fitted with drip connections, so arranged that moisture consisting of oil and water, or gasoline and distillate, is readily condensed, collected and separated from the gas and does not enter into the gas lines. The main transmission line is also equipped with similar drip connections at intervals to catch and separate from the gas any gasoline or distillate that may be condensed in the line through temperature changes. Dust screens are fitted in the manifold connections of the meter stations ahead of the meters for the purpose of screening out and catching any dust or sand that may come from the wells and be carried by the gas past the drip connections.

Production of gas in various California localities is shown by the statistics on page 116.

For the following description we are indebted to Mr. J. D. Hackstaff, manager of the Southern California Gas Company:

Description of System Supplying Los Angeles with Natural Gas.

The citizens of Los Angeles are at the present being served with natural gas obtained from the Buena Vista Hills and conveyed to the city through the Midway Gas Company's 12 inch pipe line.

The gas supply in the fields is derived both from wells producing clean dry gas and also from flowing oil wells which produce so-called casing head or tubing gas, which is given off with the oil.

When first drilled in to the producing formations dry gas wells usually develop high rock pressures running in certain portions of the field as high as 1,000 pounds. This high initial pressure or head is soon lost, however, and the wells settle down to a steady rock pressure of from 300 to 500 pounds. The rock pressure gradually declines with the exhaustion of the gas reservoirs.

Casing head or tubing gas is seldom obtained at pressures over 100 pounds, and is usually received into the gathering lines at from 25 to 50 pounds.

A comprehensive system of gathering lines collects the gas from all sources and conveys it to the main compressing station situated about five miles from Taft. These gathering lines are so designed that it is possible to keep separate the high and low pressure gas. Any gas with an original pressure in excess of that maintained on the field end of the pipe can be delivered directly into that line. All gas received into the gathering system at lower pressures, however, must be compressed or pumped to get it into the line. In time, with declining rock pressures, it will be of course necessary to pump most of the gas, especially during the peak demands when the initial pressure on the pipe line will be over 400 pounds.

Previous to the installation of the low pressure gathering system and of the compressor station, it was impossible to use any of the casing head gas. This gas was therefore of necessity allowed to blow into the air and lost forever. In order to prevent this economic waste and to conserve for the public, and finally put to use every possible foot of gas, the Southern California Gas Company has to date expended in low pressure gathering lines and compressors over three quarters of a million dollars, it being the policy of the company to avoid by every means in its power any needless waste or exploitation of the field which will in the end react to the detriment of the public.

The compressing station at present consists of three 960 horsepower twin tandem Cooper gas engines direct connected to Hall compressor cylinders. Two of these are so-called high pressure units, the third a low pressure unit. The high pressure units are designed to compress gas from an intake pressure of 145 pounds to 400 pounds. The low pressure is designed to handle the casing head gas at the pressure it comes from the wells, compress it to 145 pounds and deliver it into the intake of the high pressure units.

The compressing station is complete with all necessary auxiliaries. The gas after each compression is passed through coils in a cooling pond to remove the heat of compression before it is delivered into the pipe line. This also extracts any gasoline which may have been formed during compression.

All field lines and the compressor station are owned by the Southern California Gas Company.

The gas is conveyed from the compressor station to the Glendale Terminal by the Midway pipe line. This line is 12 inches in diameter, constructed of plain end steel pipe joined together with Hammon couplers. On the first 60 miles of the line Paranite gaskets were used; the remaining portion is put up with Standard rubber gaskets.

This line stretches southwest 107 miles from the Taft Compressor Station to the Glendale Terminal at the northern limits of Los Angeles. The route follows almost an air line and across the Tehachapi Range. The central section of the line over the mountains is one of the most rugged pieces of pipe line construction ever undertaken.

With an initial pressure of 400 pounds and a final terminal pressure of 50 pounds, the line is capable of transporting approximately 1,000,000 feet of gas per hour. The demand for gas in Los Angeles during the peak hours is more than double that of the off hours. By utilizing the storage capacity of the line, however, and packing the pressures during the off hours, a load factor of 75 per cent can be obtained.

A minimum terminal pressure of 50 pounds at Glendale is desired for purposes of town distribution. In operating the line, the initial pressure at the compressor station is varied, according to the load demand, so as to maintain at least that amount at Glendale during the peak up to the ultimate capacity of the line.

At the Glendale terminal the gas is metered and delivered to the two distributing companies at a practically uniform pressure of 45 pounds. Each of these companies has its own individual 16-inch feeder line leading from the terminal to its gas works.

During six months of the year the daily send-out of these companies is in excess of the capacity of the pipe line, being more than double during the peak days. In order, therefore, to serve the public with a standard uniform product the year round, the companies are supplying their consumers with a mixture of half natural gas and half manufactured gas. The two gases blend perfectly and the mixed gas has a calorific value of 825 British thermal units and 19 candlepower.

SUNSET FIELD.

Development and Productiveness.

The history of development and rate of production in the Sunset Field since 1903 is clearly shown by the accompanying diagram (Fig. 32), based largely on figures furnished by the Standard Oil Company.

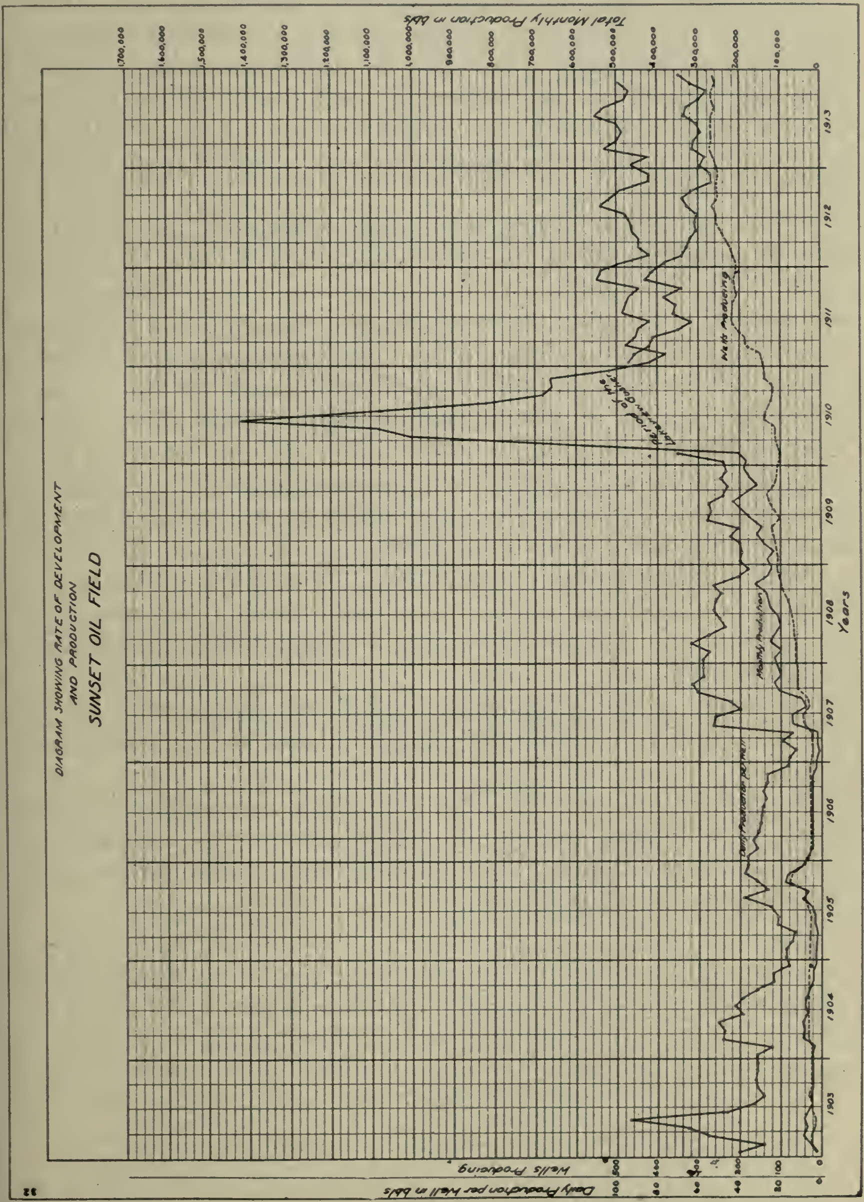

Fig. 32.

Previous to 1907, for a number of years, there was little drilling activity, the number of producing wells varying from 10 to 70, with an average daily well production of about thirty barrels, giving a total monthly production varying from 12,000 to 90,000 barrels. Most of this production was from the shallow part of the field yielding heavy oil (10° to 14° B.).

1907 to 1909.—Early in 1907 activity in drilling began and until the end of 1909 the number of producing wells was increased at the rate of about 26 per year (28 to 107). This development campaign extended into deeper territory and underlying sands with lighter oil. The average daily yield of wells was raised to about fifty barrels and the total monthly production increased from about 15,000 barrels to about 190,000 barrels.

1910 to 1913.—This period has been remarkable for the number of gushers brought in. Early in 1910 the Lakeview, the most famous well yet completed in California, began to flow at such an enormous rate that methods of transportation were entirely inadequate and great lakes of oil were held behind earthen dams. Our figures show that the total monthly production of the field jumped from 626,439 barrels in March to 1,416,490 barrels in June, a daily increase of over 26,000 barrels which was largely due to the Lakeview well. The well flowed for about a year and ceased as suddenly as it commenced; however, a number of other very good wells were brought in and at the beginning of 1911 the daily yield per well was about 90 barrels.

Drilling was continued through 1910, 1911 and 1912 at the rate of about 76 new producing wells per year, and only 29 wells during 1913. The total monthly production has been maintained since 1910 at about 475,000 barrels.

The decline of well production since 1910 has been marked but not uniform (about 12.5 barrels per year), now being about 65 barrels per well day.

The future of the field has been very briefly commented on in connection with Midway (page 221). The diagram of the Sunset Fields illustrates the variation in well production, frequently an increase, when entirely new territory is developed.

FINANCIAL RESULTS.

Financial results in the Sunset Field during the year 1913, as shown by 22 companies, producing 2,120,262 barrels of oil from 115 wells, are summarized as follows:

Capital. This figure can not be definitely determined, particularly the second item (property value), and any error here is apt to be on the side of an overestimate.

Cash paid for stock	$1,046,297 00
Property paid for stock	5,716,563 00
Total	$6,762,860 00

Dividends are difficult to determine as many concerns are close corporations, making no public reports, hence our figures may be slightly below the actual amounts. Records earlier than 1909 were not available:

1909, 3 companies	$21,527 00
1910, 5 companies	127,212 00
1911, 7 companies	211,339 00
1912, 7 companies	319,220 00
1913, 3 companies	91,936 00
	$771,234 00

The companies paying dividends produced about 452,000 barrels of oil, or 7 per cent of the field production. Further figures will be found in the table on page 10.

The following figures are not so accurate as our 1913 figures, which are correct:

Financial conditions of the Sunset District during 1912, based upon the operations of twenty-eight companies, are as follows: The 130 producing wells of these companies yielded 3,824,523 barrels in 1912, which was 69 per cent of the total output of the field.

Nine different companies are represented in the list of dividend payers. Two of these paid dividends each of four years (1909–1912) on oil of 12° to 16° B.; three paid dividends each of three years on oil of 12° to 19° B.; one paid dividends each of two years on oil of 17° to 24° B.; and one paid dividends for one year on oil of 17° to 23° B.

Of the total production, 406,776 barrels were produced by two producing companies paying dividends continuously for four years.

Cash to the amount of $826,975 was received for the total production of oil, or an average price of 21.6 cents per barrel.

Price and amount of various grades of oil during 1912 were reported as follows; some are obviously in error:

Under 15° B.	50 per cent at .066 per barrel
15.1° to 18° B.	2 per cent at .472 per barrel
18.1° to 20° B.	17 per cent at .304 per barrel
Above 20° B.	31 per cent at .389 per barrel

The price received by the nine dividend paying companies averaged about 28.5 cents per barrel. One of the companies, continuously paying dividends for four years, received about 15.9 cents per barrel on 13° gravity oil.

The total operating expense (not including depreciation, taxes, insurance, and interest, which are $587,256) averaged $12.36 daily per well, or 15.35 cents per barrel. The daily operating expense per well of seven of the dividend paying companies with 84 wells was $8.00. The operating cost per well of three companies that paid dividends for three years from 39 wells was $8.80.

These figures include costs on wells drilling, of which the total number was 31.

The daily production per well, from the figures under consideration, show the average for the field to have been 80.5 barrels, and for the companies that paid dividends, 42 barrels.

STATISTICS OF FIELD DEVELOPMENTS.

(Standard Oil Company.)

Sunset Field.

Year	Wells producing	Number of wells completed during month	Monthly production	Barrels per well per day
1903.				
January	10		12,400	40
February	27		21,000	28
March	27		46,500	55
April	19		37,400	65
May	18		52,235	93
June	24		33,300	46
July	26		26,350	33
August	32		27,590	28
September	25		23,100	31
October	25		25,110	32
November	25		23,400	31
December	25		24,180	31
Total			352,565	
1904.				
January	25		24,180	31
February	25		17,400	24
March	32		47,895	48
April	32		45,000	47
May	32		49,600	50
June	32		36,000	38
July	33		43,400	42
August	33		38,750	38
September	32		30,000	31
October	31		21,700	23
November	31		21,000	23
December	31		15,500	16
Total			390,425	
1905.				
January	30		15,500	17
February	30		14,000	17
March	29		12,400	14
April	29		11,462	13
May	29		18,600	21
June	29		18,000	21
July	34		24,800	24
August	40		47,160	38
September	40		31,890	27
October	79		91,800	32
November	74		84,000	38
December	43		49,600	37
Total			419,212	
1906.				
January	32	1	37,200	37
February	28	1	25,200	32
March	27	1	28,210	34
April	28		26,250	31
May	28		26,040	30
June	28		25,200	30
July	28		26,040	29
August	28		24,800	28
September	28		24,000	29
October	30	2	25,110	27
November	30	1	24,000	27
December	30		15,500	17
Totals		6	307,550	

Sunset Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production	Barrels per well per day
1907.				
January	28	1	13,950	16
February	23	------------	8,400	13
March	25	------------	11,625	19
April	24	------------	11,250	15
May	44	1	72,675	53
June	47	------------	73,500	52
July	30	------------	37,200	40
August	34	2	48,825	45
September	56	3	103,370	61
October	59	------------	115,785	63
November	57	2	100,500	58
December	60	4	107,725	58
Totals	------------	13	704,805	
1908.				
January	64	1	114,700	58
February	62	1	99,325	55
March	64	3	126,525	64
April	68	1	112,200	55
May	68	1	100,285	47
June	71	5	105,550	48
July	76	5	125,395	53
August	81	9	130,870	52
September	91	7	135,200	49
October	99	5	162,045	53
November	104	5	130,050	41
December	107	3	121,365	36
Totals	------------	46	1,463,510	
1909.				
January	103	2	132,525	40
February	108	4	117,600	39
March	113	3	141,050	40
April	117	8	158,850	45
May	122	8	145,235	41
June	102	1	172,800	56
July	115	9	193,805	54
August	127	6	216,520	55
September	132	5	189,833	48
October	116	5	166,076	46
November	109	------------	175,412	59
December	107	7	189,995	57
Totals	------------	58	1,999,701	
1910.				
January	102	3	182,838	58
February	103	10	203,153	70
March	109	6	626,439	
April	113	4	1,103,730	
May	111	6	1,182,402	
June	139	9	1,416,490	
July	135	6	1,165,786	
August	126	8	828,655	
September	118	6	679,230	
October	117	5	657,417	
November	137	8	660,210	
December	138	8	512,554	
Totals	------------	79	9,218,904	

Sunset Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production	Barrels per well per day
1911.				
January	143	7	418,096	94
February	148	2	377,636	91
March	184	4	479,539	84
April	185	9	453,030	82
May	205	11	447,733	70
June	219	4	415,410	63
July	217	12	485,150	72
August	216	13	479,756	71
September	204	9	470,670	77
October	210	8	443,579	68
November	212	8	548,760	86
December	208	7	539,710	83
Totals	----------	94	5,559,069	
1912.				
January	205	6	491,226	77
February	213	7	418,267	68
March	220	5	447,795	66
April	232	9	442,950	64
May	244	4	461,621	61
June	252	5	466,320	62
July	252	4	475,106	61
August	264	7	540,299	66
September	250	6	512,520	68
October	251	2	490,265	63
November	252	1	423,630	54
December	249	----------	420,825	54
Totals	----------	56	5,590,824	
1913.				
January	254	4	465,930	59
February	263	2	421,456	57
March	270	----------	530,875	63
April	266	3	495,450	62
May	266	2	485,987	59
June	267	8	490,620	61
July	264	2	552,358	67
August	258	3	530,720	66
September	265	1	478,050	60
October	267	1	467,325	56
November	256	1	493,000	64
December	262	2	572,880	70
Totals	----------	29	5.984.651	

Midway-Sunset Fields Combined.

1914.				
January	1,214	14	3,776,451	100
February	1,236	20	3,747,016	108
March	1,242	22	4,110,538	107
April	1,262	16	4,259,340	112
May	1,330	15	4,277,039	104
June	1,367	27	4,413,540	108
July	1,400	21	4,635,833	107
August	1,403	24	4,539,764	104
September	1,422	21	4,433,310	104
October	1,353	11	4,422,398	105
November	----------	----------	----------	----------
December	----------	----------	----------	----------
Totals	----------	----------	----------	----------

DIRECTORY OF COMPANIES OPERATING IN SUNSET FIELD.

Company	Location	Wells completed	Gravity	Official address
Adeline	3-11-24	3	--------	Maricopa.
Adeline	2-11-24	22	13.2	
American Oil Fields	14-11-23	--------	19.0	Los Angeles.
American Oil Fields	15-11-23			
Anglo-Maricopa	24-11-23	--------	--------	307 Chronicle Bldg., San Francisco.
Anaconda	12-11-23	3	13.0	Maricopa.
August	6-11-23	2	21.2	Box 838, Fresno.
Broncho	8-11-23	1		
*Boston Pacific	34-12-24	5	12.9	769 Monadnock Bldg., San Francisco.
Buick	29-11-23	--------	--------	815 Storey Bldg., Los Angeles.
California Amalgamated	32-12-23	1	--------	533 Phelan Bldg., San Francisco.
Canadian Sunset	6-11-23			
Canadian Sunset	7-11-24	1		
Comstock Crude	34-12-23			
Conservative	12-11-24	2	--------	Maricopa.
El Camino	10-11-23	--------	--------	501 First National Bank Bldg., Oakland.
El Dora	32-12-23	2	19.5	First National Bank Bldg., Pomona.
*Ethel D.	36-12-24	15	18.9	Union National Bank Bldg., Fresno.
Fulton	1-11-24	31	13.0	
General Petroleum	6-11-23*	7	21.3	Alaska Commercial Bldg., San Francisco.
General Petroleum	10-11-23			
General Petroleum	35-11-23			
General Petroleum	32-12-23	3	21.0	
Hanford Sanger	3-11-24	4	--------	618 I. W. Hellman Bldg., Los Angeles.
Haselton Crude	17-11-23	1		
Ida May	2-11-24	4	13.0	760 Mission st., San Francisco.
Interstate	4-11-23			
*Johnson	7-11-23	1	--------	Union National Bank Bldg., Fresno.
K. D.	4-11-23			
Kern Trading and Oil	31-12-23	21	22.0	917 Flood Bldg., San Francisco.
Kern Trading and Oil	1-11-24	11	19.0	
Kern Trading and Oil	25-12-24	9	18.0	917 Flood Bldg., San Francisco.
Kern Trading and Oil	5-11-23	6	23.0	
La Blanc	6-11-23	2	18.4	401 Security Bank Bldg., Oakland.
*Lakeview No. 2	4-11-23	2	26.0	1114 Union Oil Bldg., Los Angeles.
Los Angeles Midway	32-12-24	--------	--------	321 I. W. Hellman Bldg., Los Angeles.
Manitoba	7-12-24	--------	--------	928 Central Bldg., Los Angeles.
Maricopa Star	32-12-23	7	22.0	
Maricopa Producers	8-11-23			
Maricopa Northern	32-12-23	2	22.0	346 Title Insurance Bldg., Los Angeles.
*Maricopa National	6-11-23	3	21.3	Maricopa.
Maricopa No. 36	36-12-24	4	--------	Maricopa.
Maricopa Union	6-11-23	1	21.6	
Maricopa Visalia	20-11-23			
*McCutheon	2-11-24	8	13.0	Maricopa.
*Miocene	32-12-23	2	21.2	
Midas	26-12-23			
Midway Southern	8-11-23			
Midland (see American)	32-12-23	2	16.0	
Midway Field	4-11-23	--------	13.0	Box 696, Los Angeles.
Midway View	2-11-24	2	13.0	Union League Bldg., Los Angeles.
Midway Northern	32-12-23	4	23.0	I. W. Hellman Bldg., Los Angeles.
M. J. & M. M. (M. J.)	36-12-24	4	22.0	1432 Broadway, Oakland.
M. J. & M. M. (N. E.)	36-12-24	4	18.0	
M. J. & M. M. (S. W.)	36-12-24	14	18.6	
M. J. & M. M. (N. M.)	36-12-24	6	19.0	
Mohawk Sunset	1-11-24	--------	--------	140 Forsythe Bldg., Fresno.
Monte Cristo	1-11-24	18	16.0	323 Balboa Bldg., San Francisco.
M. T.	36-12-24	3	21.0	
*Muscatine	1-11-24	5	12.2	Maricopa.
Munzer & Lee	7-11-23			
National Pacific	30-12-23	2	23.4	Wright & Callender Bldg., Los Angeles.
National Pacific	32-12-23	2	20.0	
Nevada Pacific	24-11-23			
New Center	12-11-24	6	12.5	California Pacific Bldg., San Francisco.

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*Member Independent Oil Producers' Agency.

Companies Operating in Sunset Field—Continued.

Company	Location	Wells completed	Gravity	Official address
Norris Midway	34-12-23	--------	--------	Maricopa.
Northern	12-11-24	--------	--------	Maricopa.
Obispo	32-12-23	3	26.0	Commercial Bank Bldg., San Luis Obispo.
Pacific Midway	32-12-23	3	22.2	507 Montgomery st., San Francisco.
Panama	32-12-23	2	18.2	Bakersfield.
Panama American	32-12-23	--------	--------	503 I. W. Hellman Bldg., Los Angeles.
Petrolia	12-11-24	2	13.0	Tulare.
Phoenix Interstate	3-11-24			
Rialto	34-12-23			
Rio	3-11-24			
Ripley & Barbour	12-11-23			
*Ruby	2-11-24	10	13.9	805 Security Bldg., Los Angeles.
Seaboard O. and T.	1-11-24	12	--------	404 Wilcox Bldg., Los Angeles.
Section "12"	12-11-24	1	--------	1822 Chester ave., Bakersfield.
*Snook, Walter	12-11-24	4	12.8	Maricopa.
South End	21-11-23			
Spreckels	32-12-23	5	21.0	Chronicle Bldg., San Francisco.
Sunset Monarch	26-12-24	7	19.6	60 Clay st., San Francisco.
Sunset Monarch	2-11-24	31	13.8	
Sunset Rex	2-11-24	3	13.0	2750 Raymond ave., Los Angeles.
Security	29-11-23			
Sunset Extension	8-11-23	--------	--------	801 Barland Bldg., Los Angeles.
*Tannehill	34-12-24	12	12.8	
Test	34-11-23			
34 Hill	34-11-23			
Topaz	12-11-24	2	14.0	Box 34, Bakersfield.
Union	4-11-23	1	--------	Taft.
Union (Lakeview)	25-12-24	4	16.0	
Union	33-12-24	2		
Union	34-12-24			
Union	35-12-24	36	15.8	
Union	18-11-23			
Union	13-11-24	6		
United Crude	2-11-24	6	13.7	Maricopa.
Vancouver Midway	1-11-24	1	--------	805 Dominion Trust Bldg., Vancouver.
Vancouver Paraffine	23-11-23			
Western Minerals	17-11-23	3	--------	704 West Coast Life Bldg., San Francisco.
Western Minerals	22-11-23	2		
Western Minerals	28-11-23	1		
West Virginia	6-11-23	1	--------	508 Higgins Bldg., Los Angeles.
Total	----------	420		

*Member Independent Oil Producers' Agency.

Amount of oil produced during 1913 by the various companies is indicated by figures on pages 31, 35, 39, 41.

LIFE OF WELLS.

The records for six years in Midway and eleven years in Sunset show practically no wells abandoned on account of exhaustion.

The accompanying diagrams (pages 267–287) afford some basis for statements as to what may be expected of average wells. The diagrams show for each month the total daily production, the number of wells producing and the average daily production per well. As in the description of Coalinga wells, to which the reader's attention is particularly directed, the figures for total production are accurate, while those for a number of wells are subject to slight error owing to occasional shut-downs by individual wells.

A general statement seems justifiable that where wells are brought in as gushers the first year may be expected to show a decline in production of at least 25 per cent, and possibly even 50 per cent, and then the rate of decline is slower, averaging each month from one to two barrels per well day. From the first well on a new property, with no producing wells closer than about a quarter of a mile, a large initial production may be expected, frequently over a thousand barrels per day. After a few weeks or even days such wells fall off very fast and succeeding wells drilled near by may not be expected to show an initial production much greater than the reduced production of the original well.

As most oil properties, to be profitable, require several wells (seldom less than five), the figures showing average production per well are most useful in estimating future economic work.

The average decline in production per well day is shown by these diagrams to be 1.0 barrel for Midway and 1.7 barrels for Sunset, which is supported in a general way by the diagrams of the entire field, which show .71 and 1.03, respectively.

Summary of Production Diagrams, Midway Field.

Group	Gravity	Feet of oil sand	Acres per well	Period gradual decline, months	Loss in barrels monthly
A	25	87	10	21	2.6
B	20	118	5	12	2.7
C	14	136	4	31	2.6
D	24	160	9	18	3.9
E	19	189	8	13	.4
F	21	117	5	15 14	11.3 18.9
G	14	289	3	----------	----------
H	13	186	5	22	1.6
I	23	16	7	----------	----------
J	23	42	6	16	9.2
K	19	75	7	21	10.0
L	17	29	10	23	1.6
M	14	147	3	30	.9
N	13	----------	4	35	.6
O	14	94	5	48	1.0
P	15	140	4	38	2.5
Q	22	72	4	----------	----------
R	13	----------	5	16	2.2
S	18	127	8	----------	----------
T	13	----------	5	----------	----------
				Average	1.0

Sunset Field.

Group	Gravity	Feet of oil sand	Acres per well	Period gradual decline, months	Loss in barrels monthly
A	20	23	10	----------	----------
B	12	142	2	64	1.5
C	17	----------	10	17	3.2
D	18	64	10	30	2.8
E	12	135	4	43	.9
F	16	92	8	18 30	3 7 .6
G	23	99	9	26	2.0
H	14	93	3	54	.4
I	13	40	4	51	.6
				Average	1.7

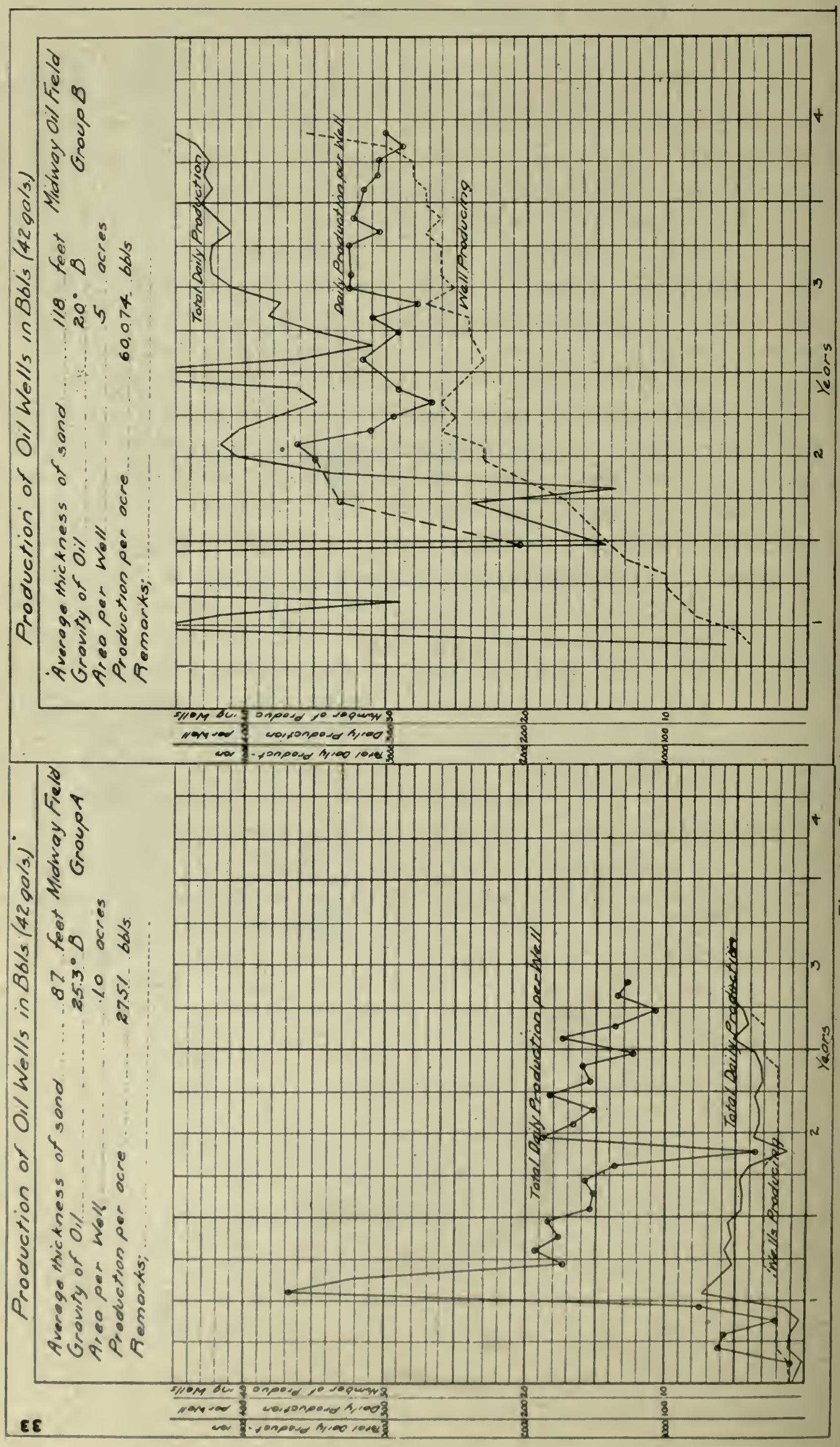


Fig. 33. Production record of 40 wells.

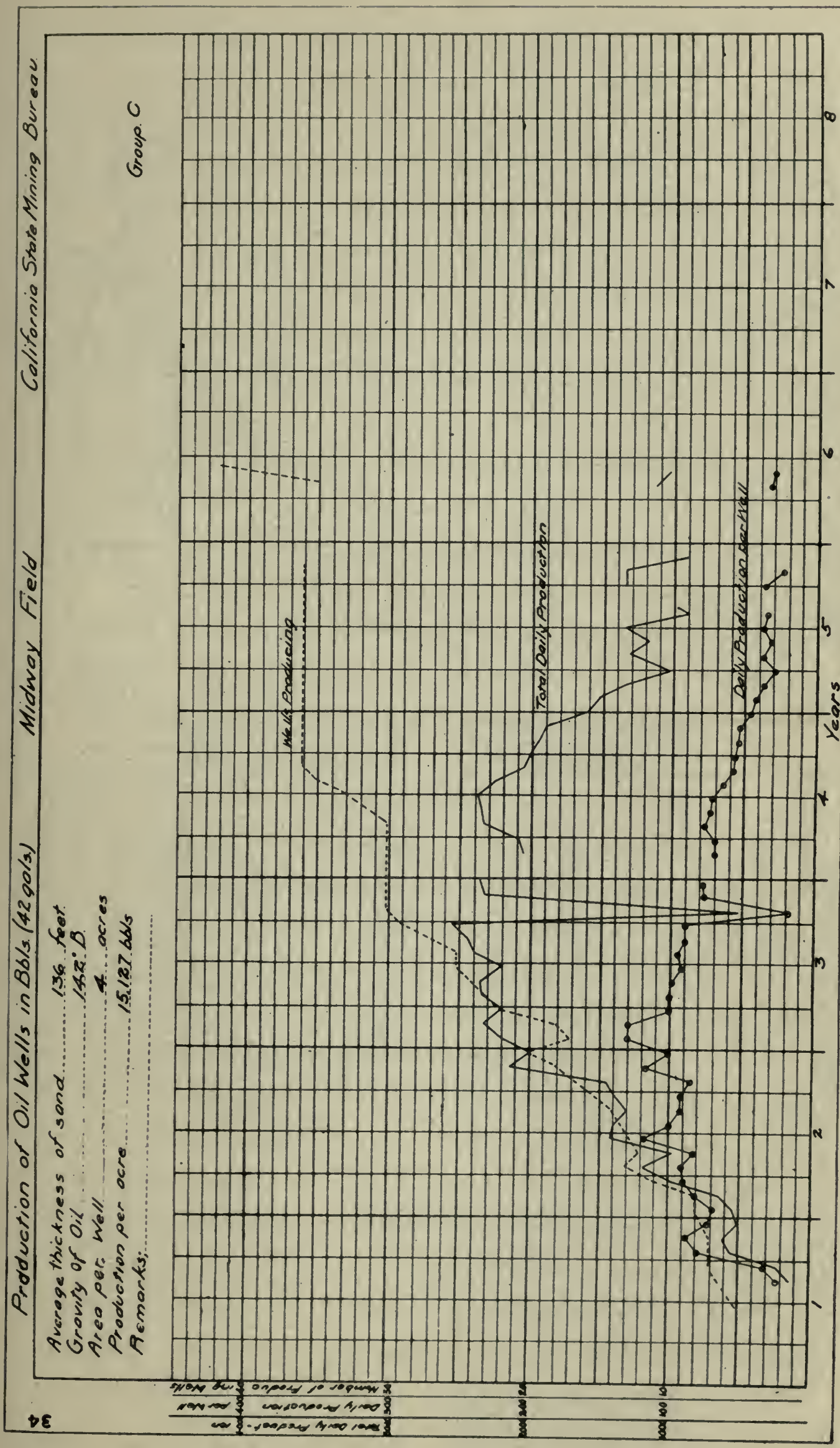


Fig. 34. Production record of 36 wells.

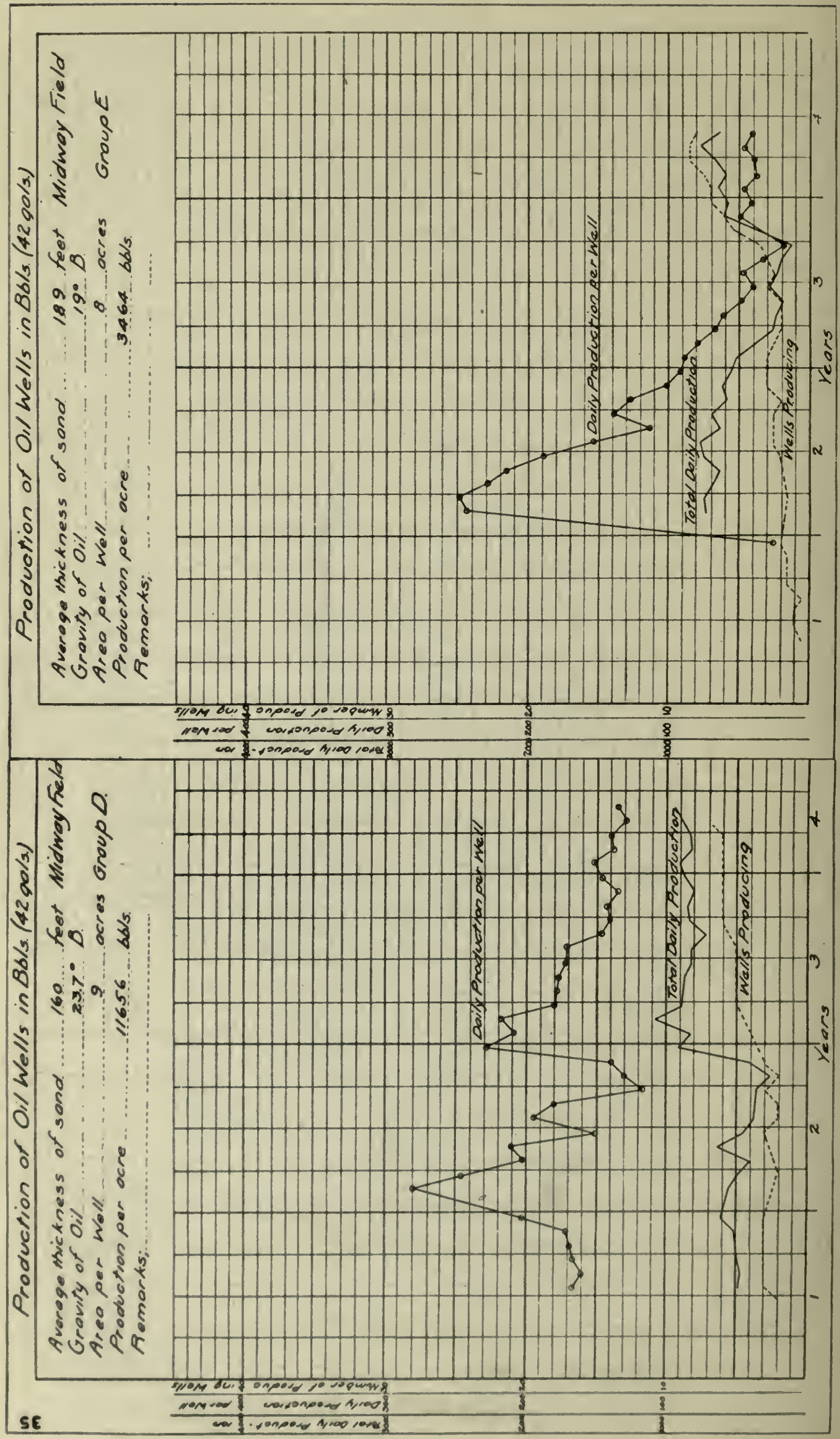


Fig. 35. Production record of 16 wells.

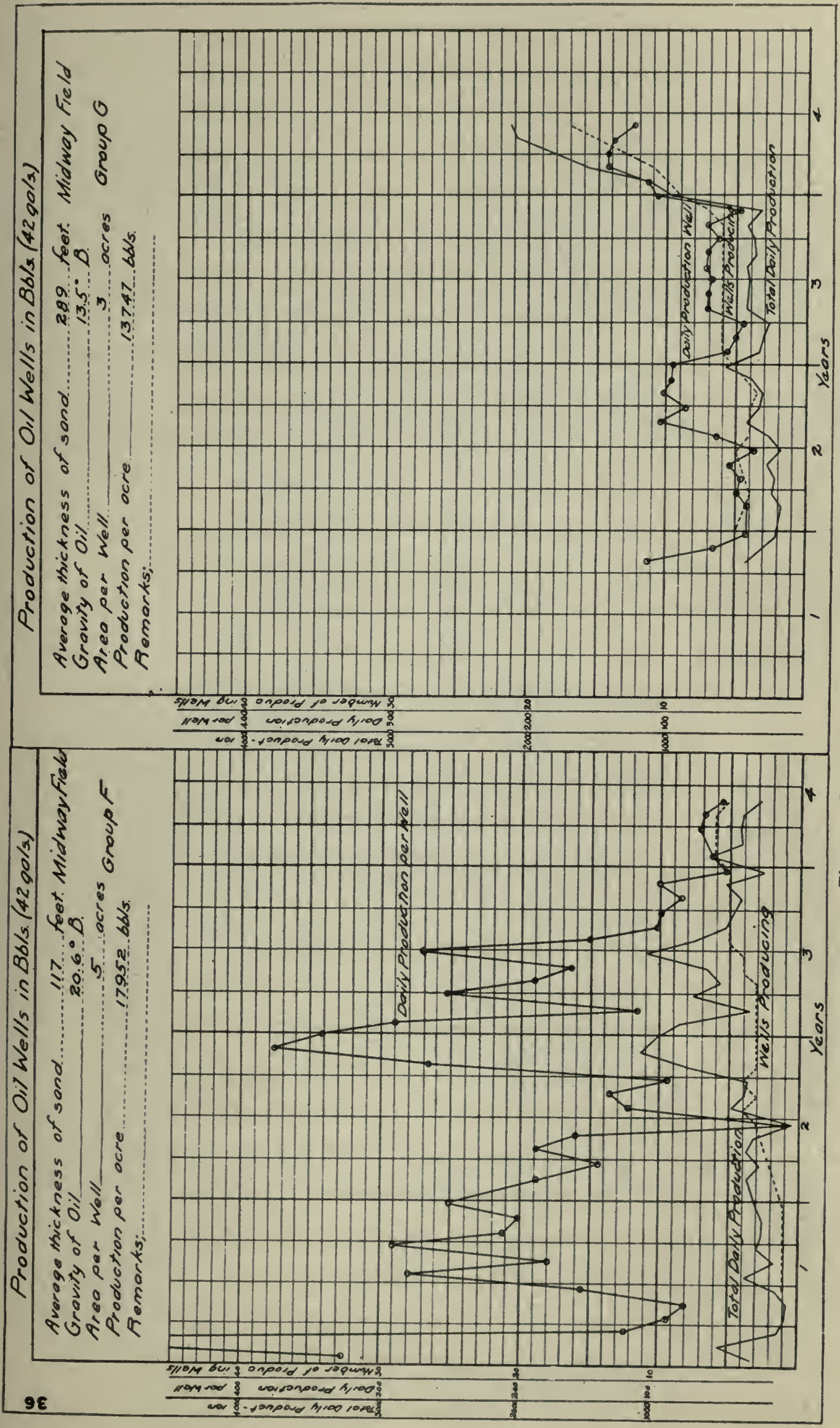


Fig. 36. Production record of 23 wells.

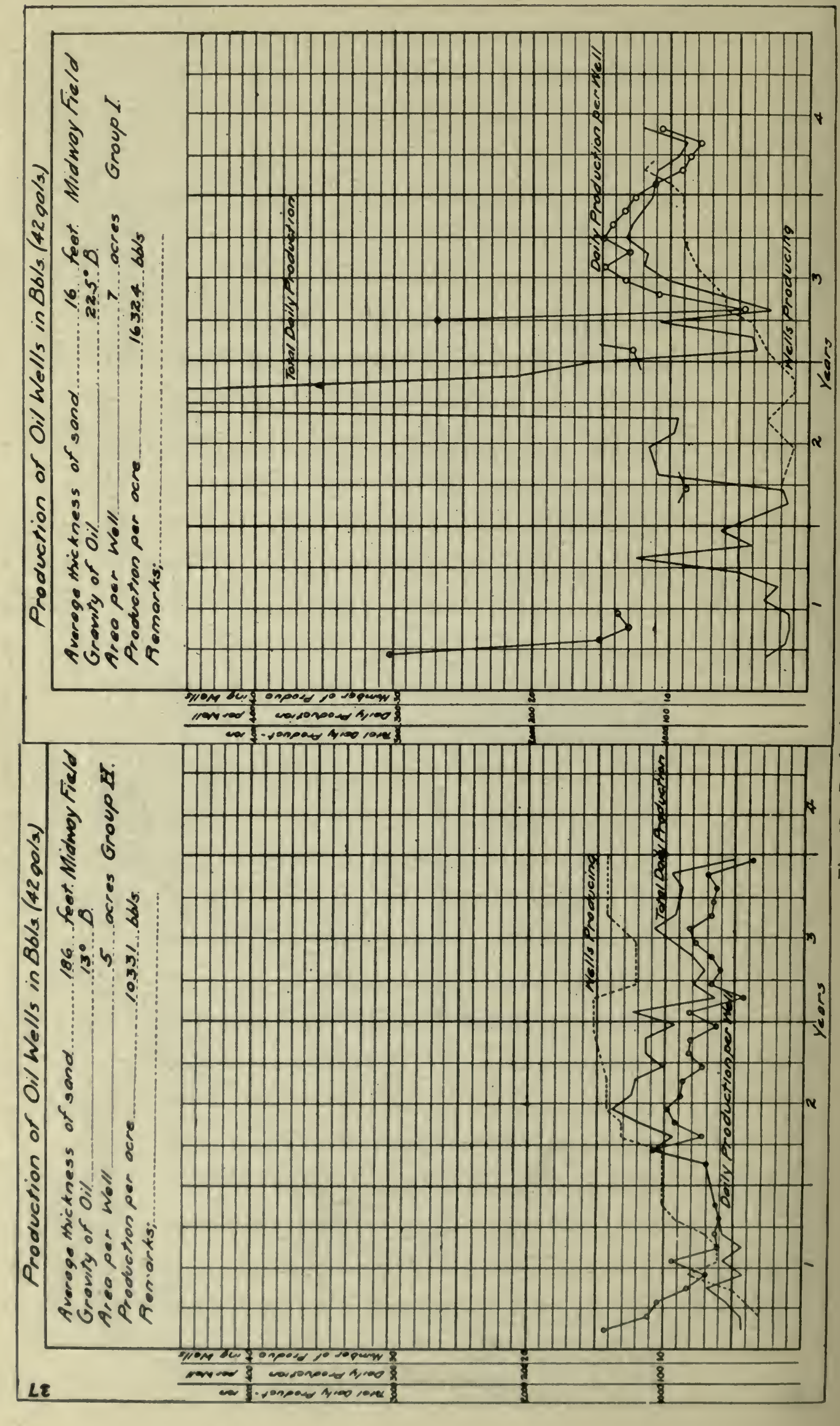


Fig. 37. Production record of 27 wells.

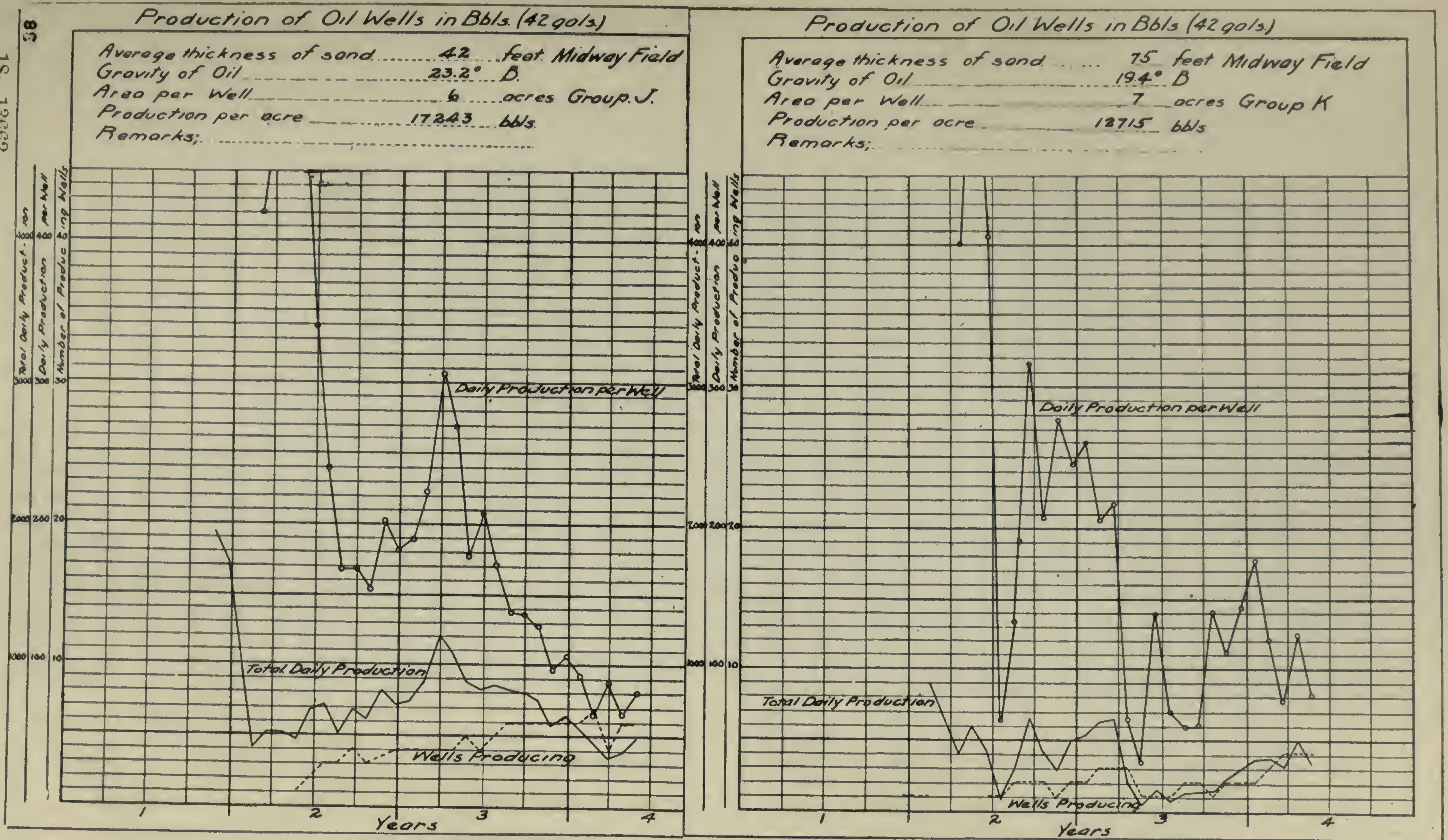
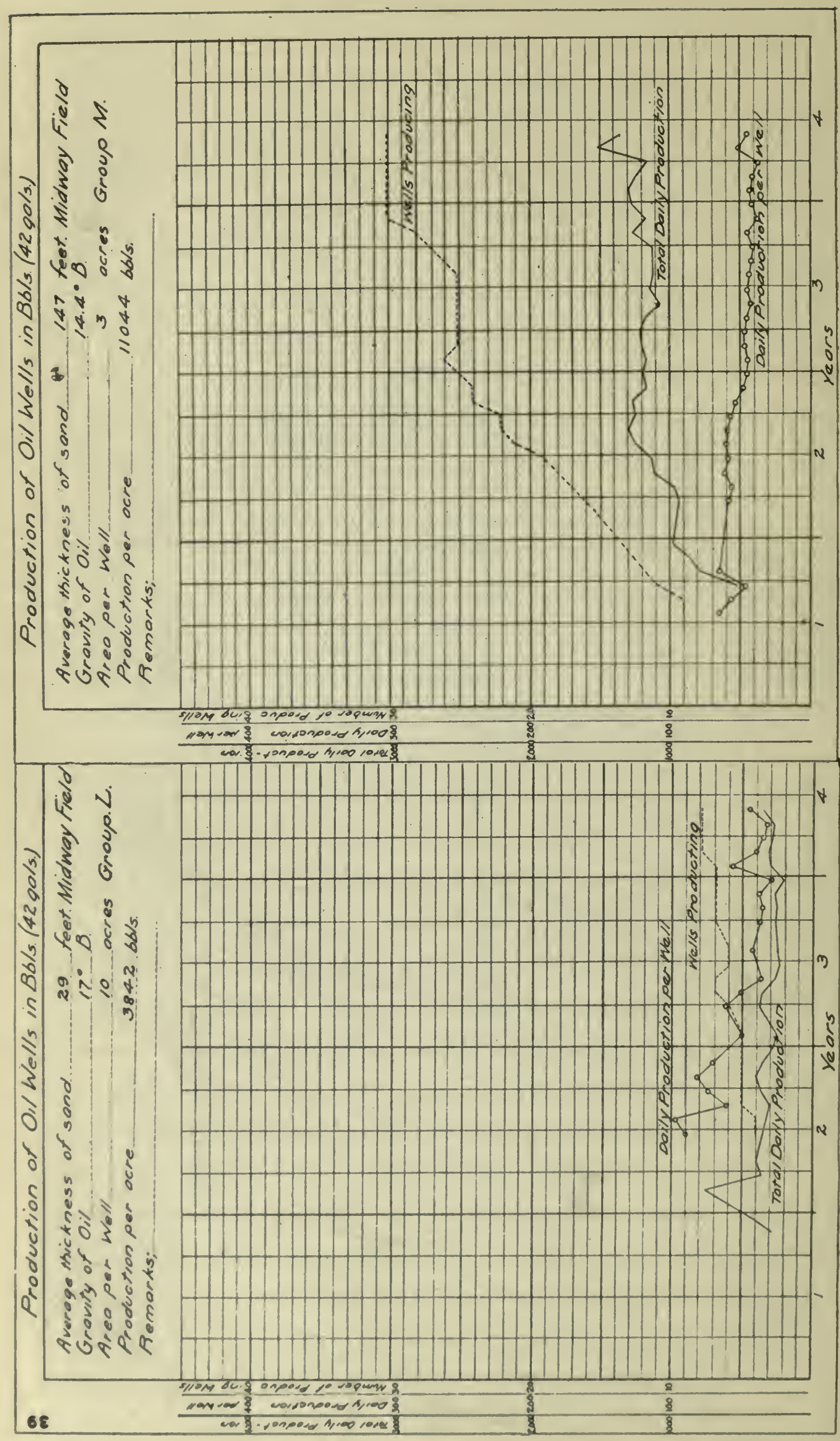


Fig. 38. Production record of 11 wells.



Production of Oil Wells in Bbls. (42 gals.)

Average thickness of sand 147 feet. Midway Field
Gravity of Oil 14.4° B.
Area per Well 3 acres Group M.
Production per acre 11044 bbls.
Remarks;

Production of Oil Wells in Bbls. (42 gals.)

Average thickness of sand 29 feet. Midway Field
Gravity of Oil 17° B.
Area per Well 10 acres Group. L.
Production per acre 3842 bbls.
Remarks;

Fig. 39. Production record of 38 wells.

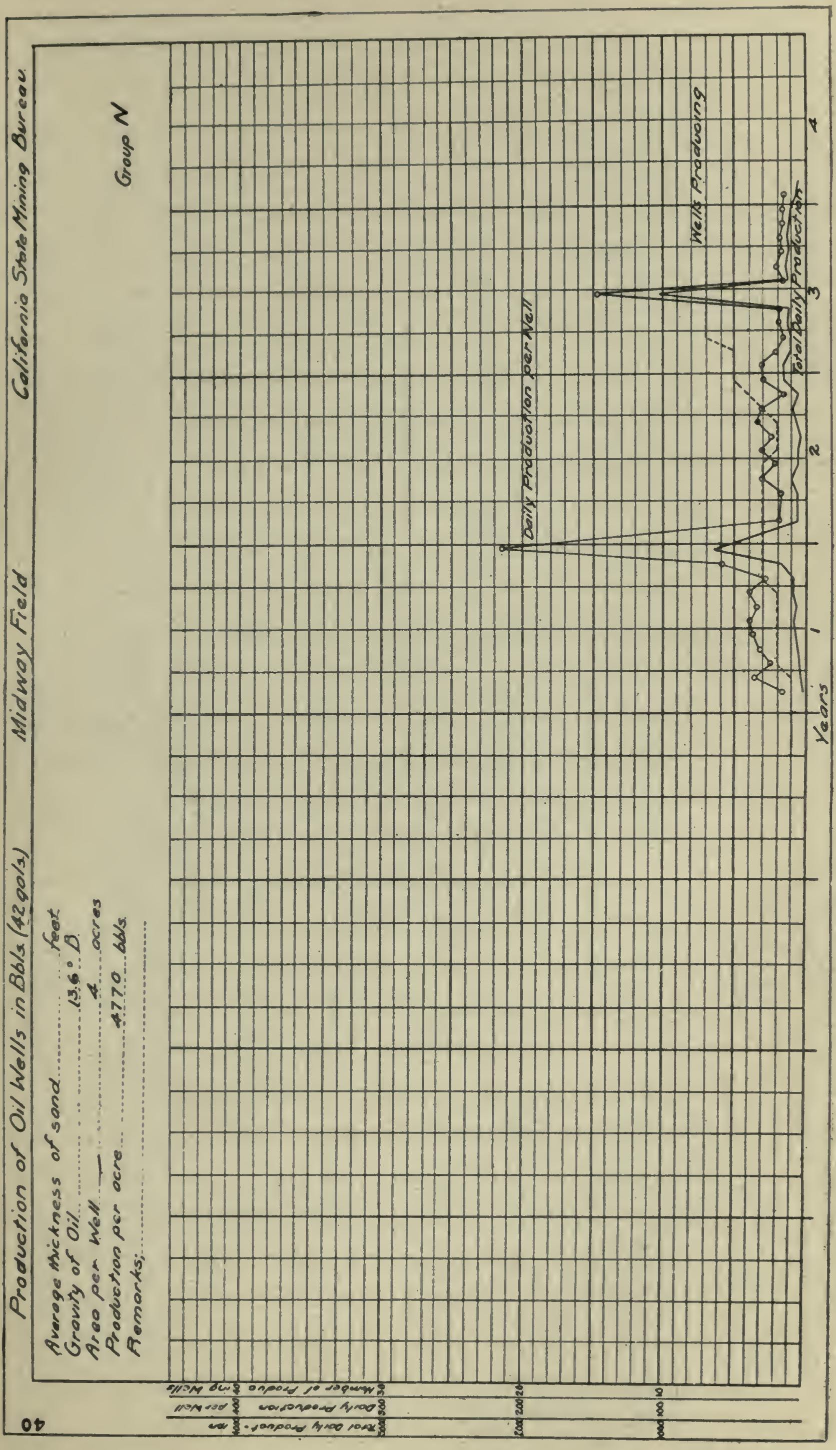
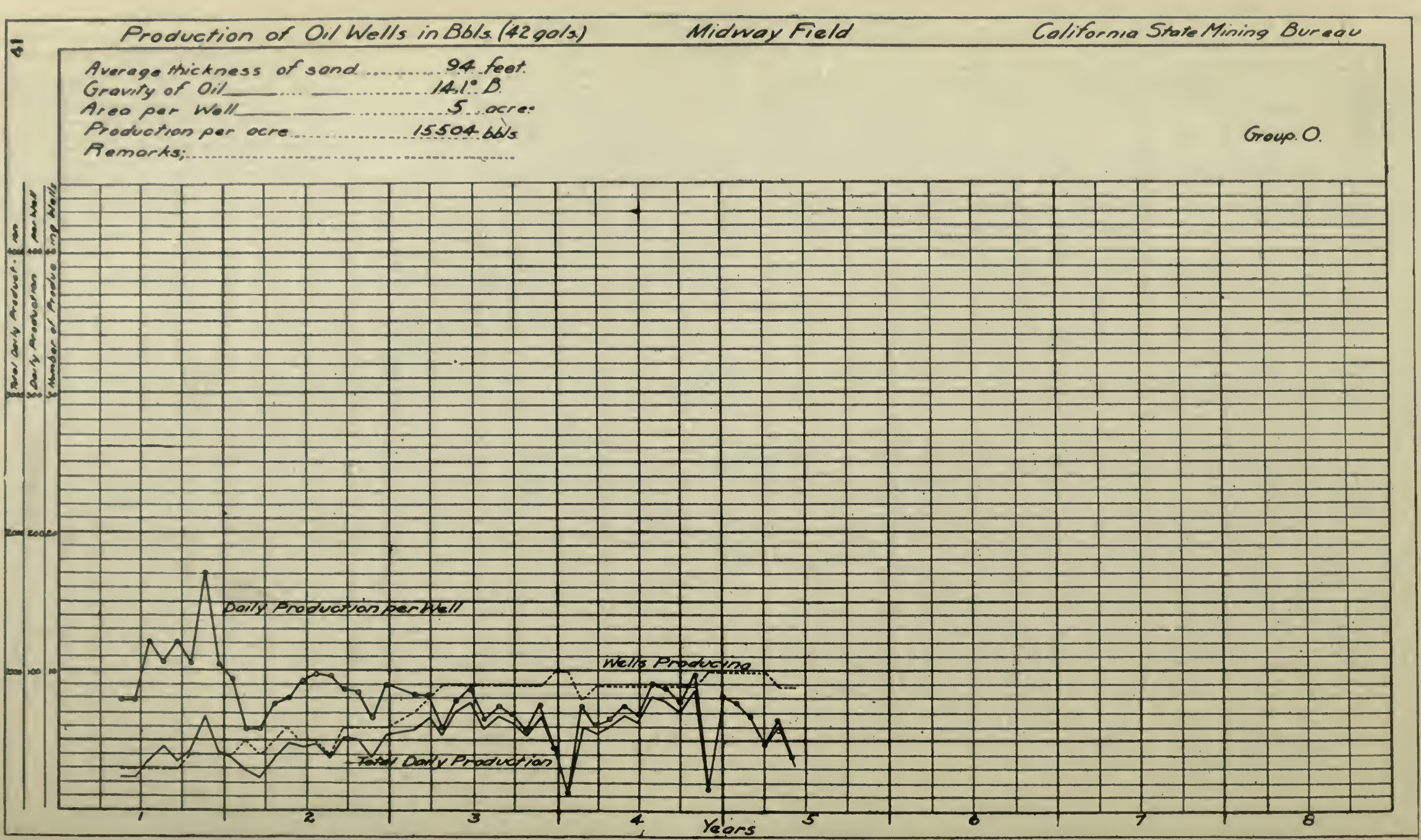


Fig. 40. Production record of 7 wells.



Production of Oil Wells in Bbls. (42 gals.) Midway Field California State Mining Bureau

41

Average thickness of sand .... 94 feet.
Gravity of Oil .... 14.1° B.
Area per Well .... 5 acres
Production per acre .... 15504 bbls.
Remarks; ....

Group. O.

Fig. 41. Production record of 10 wells.

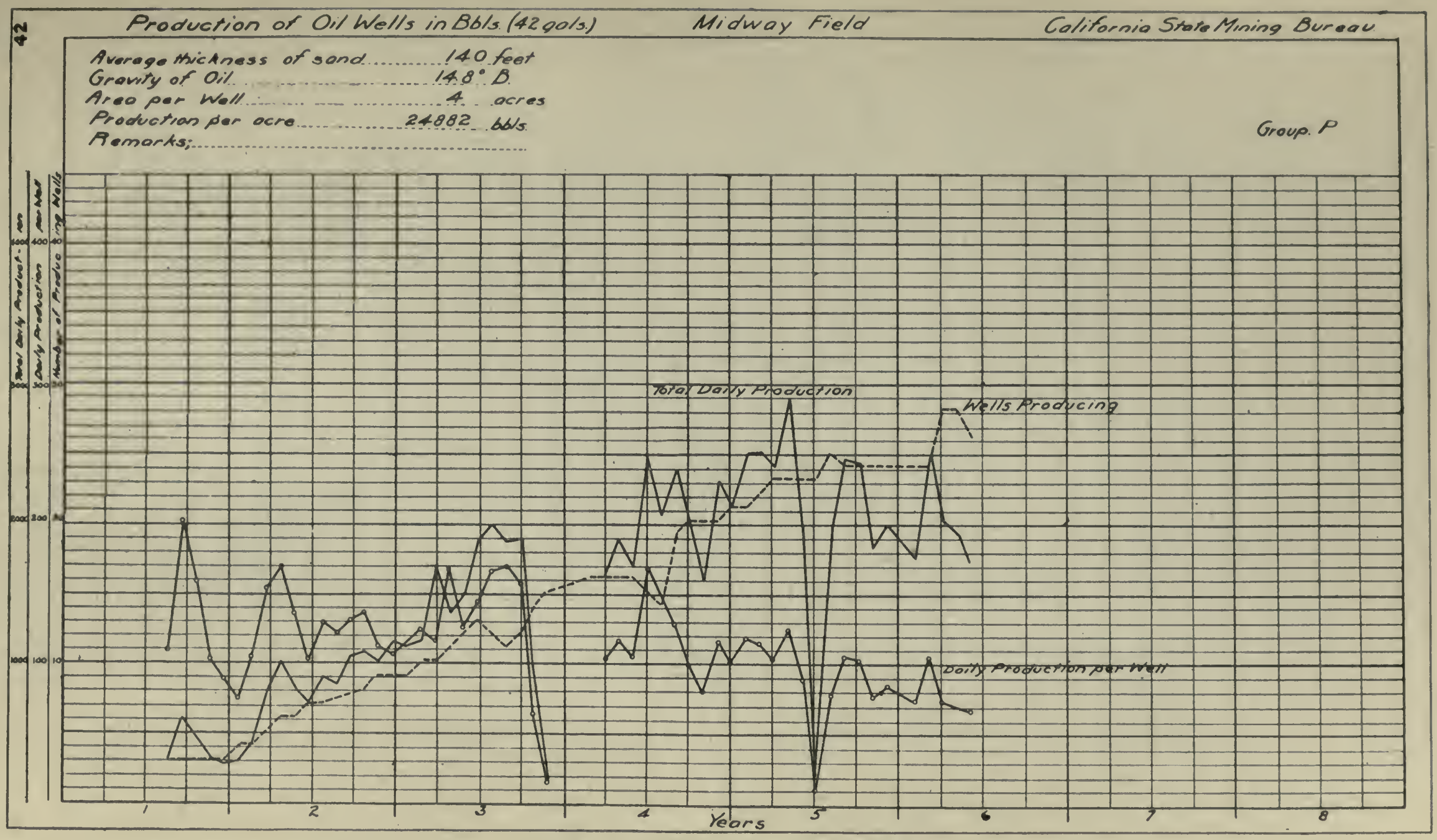
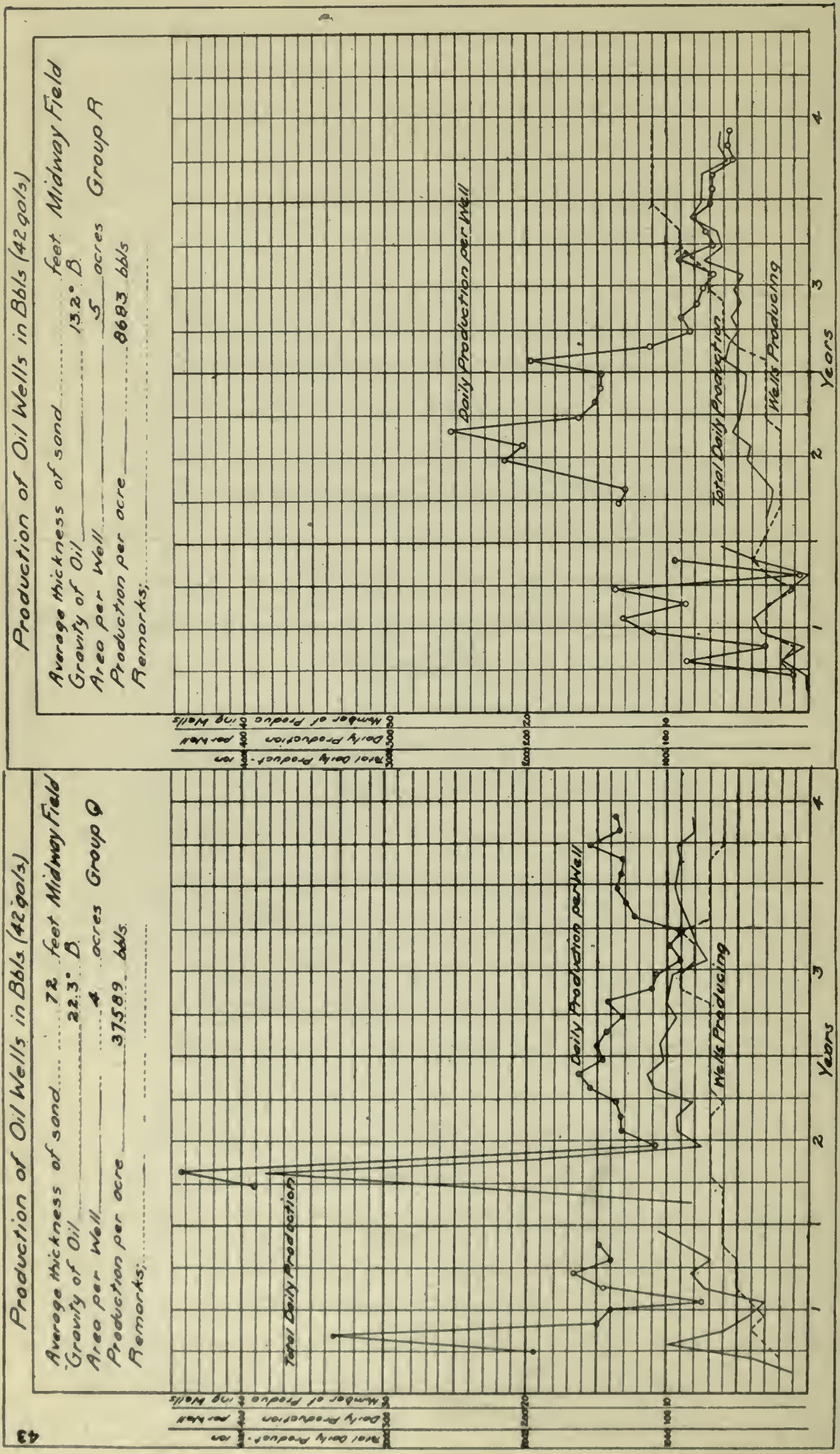


Fig. 42. Production record of 28 wells.



Production of Oil Wells in Bbls (42 gals)

Average thickness of sand 72 feet Midway Field
Gravity of Oil 22.3° B.
Area per Well 4 acres Group Q
Production per acre 37589 bbls.
Remarks;

Production of Oil Wells in Bbls (42 gals)

Average thickness of sand feet Midway Field
Gravity of Oil 13.2° B.
Area per Well 5 acres Group R
Production per acre 8683 bbls
Remarks;

Fig. 43. Production record of 20 wells.

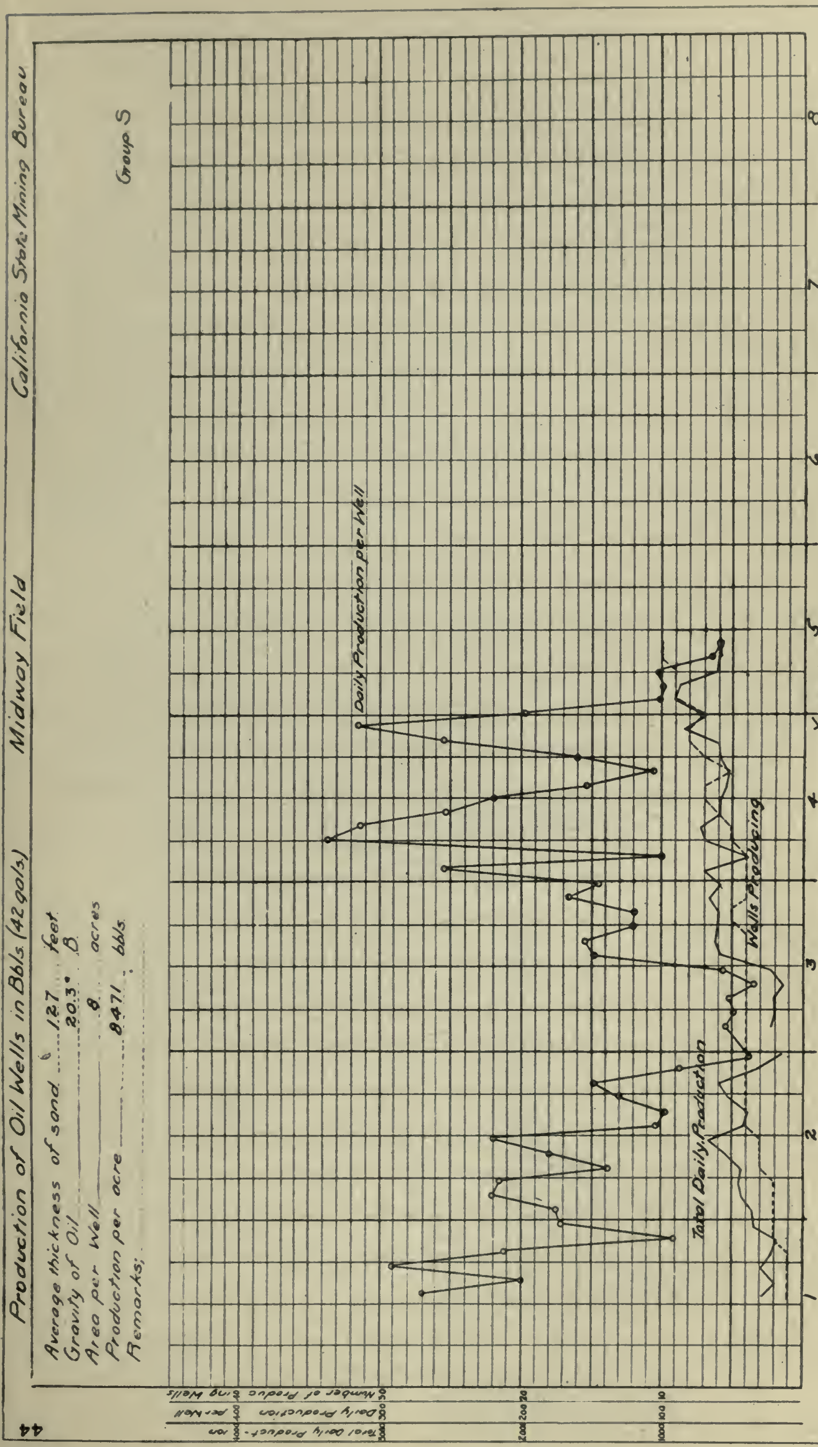


Fig. 44. Production record of 10 wells.

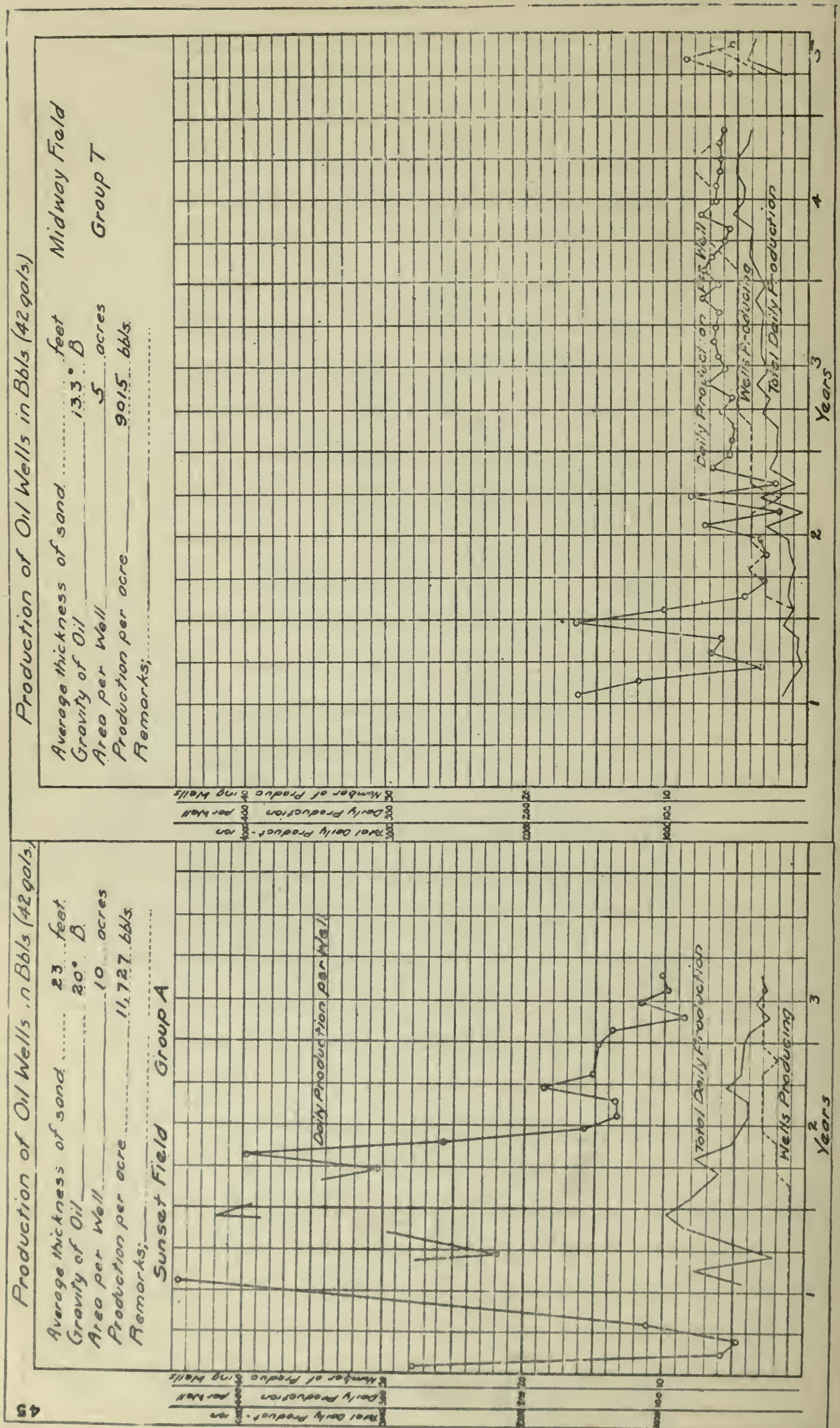


Fig. 45. Production record of 11 wells.

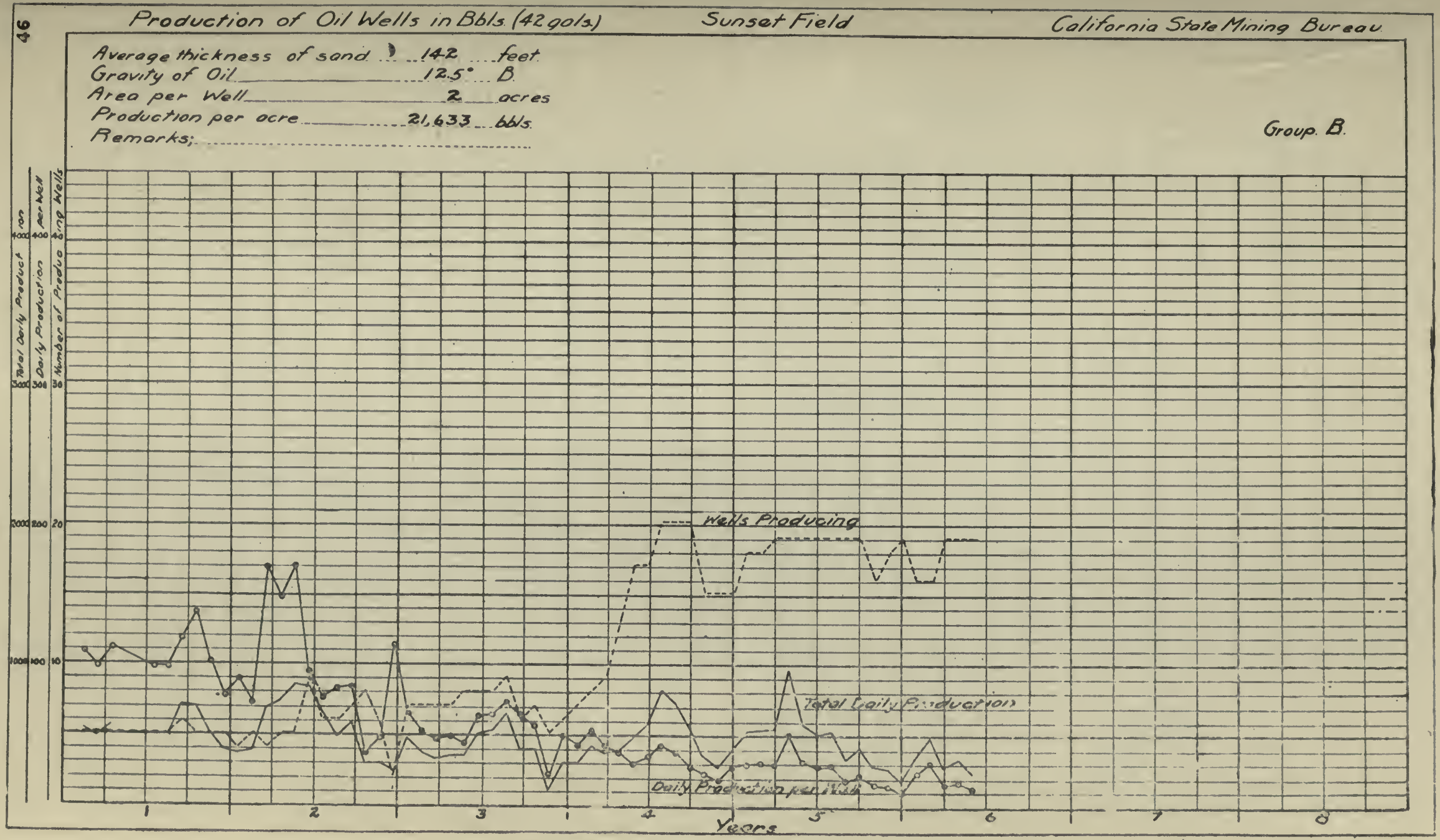


Fig. 46. Production record of 20 wells.

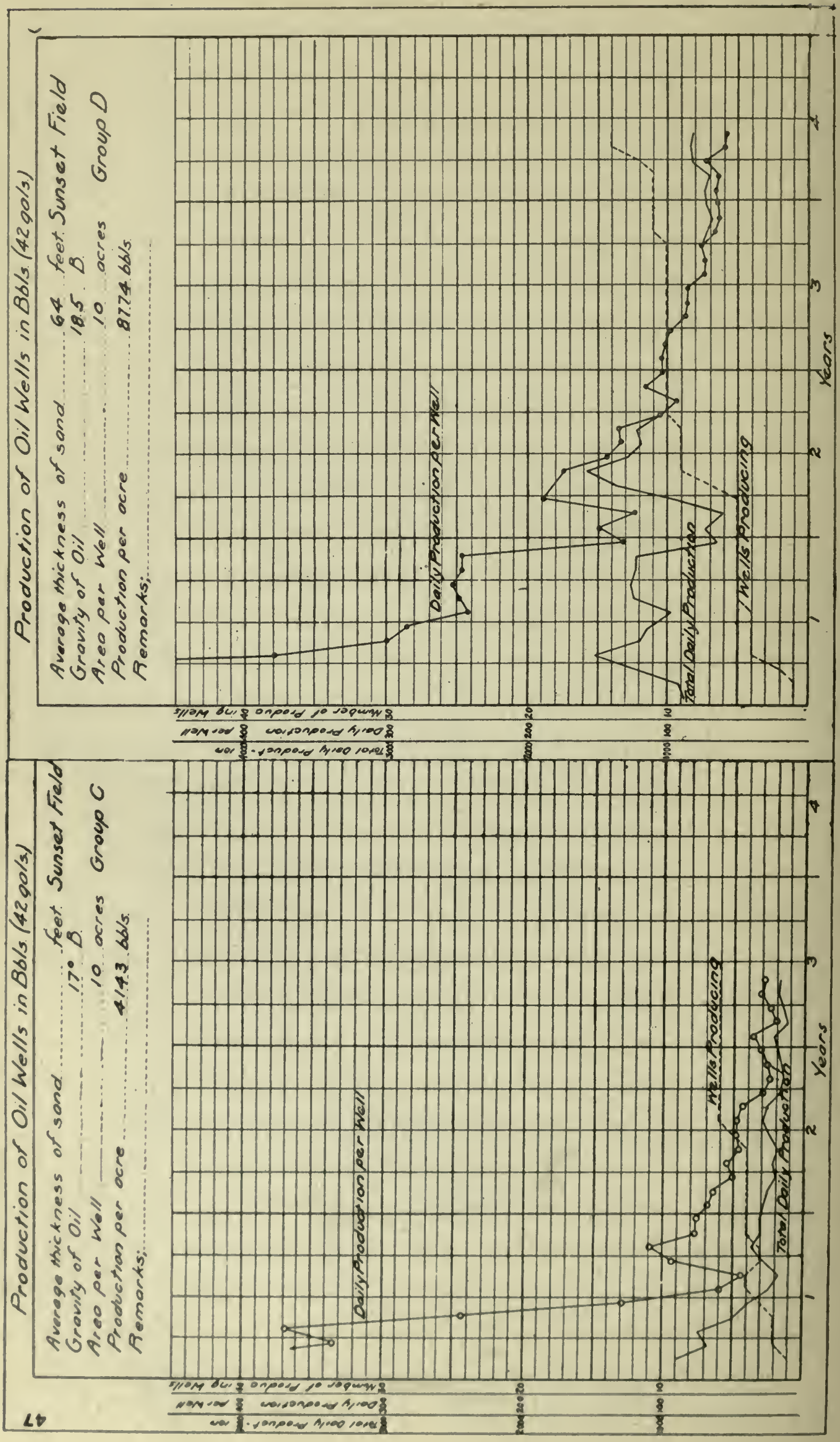


Fig. 47. Production record of 20 wells.

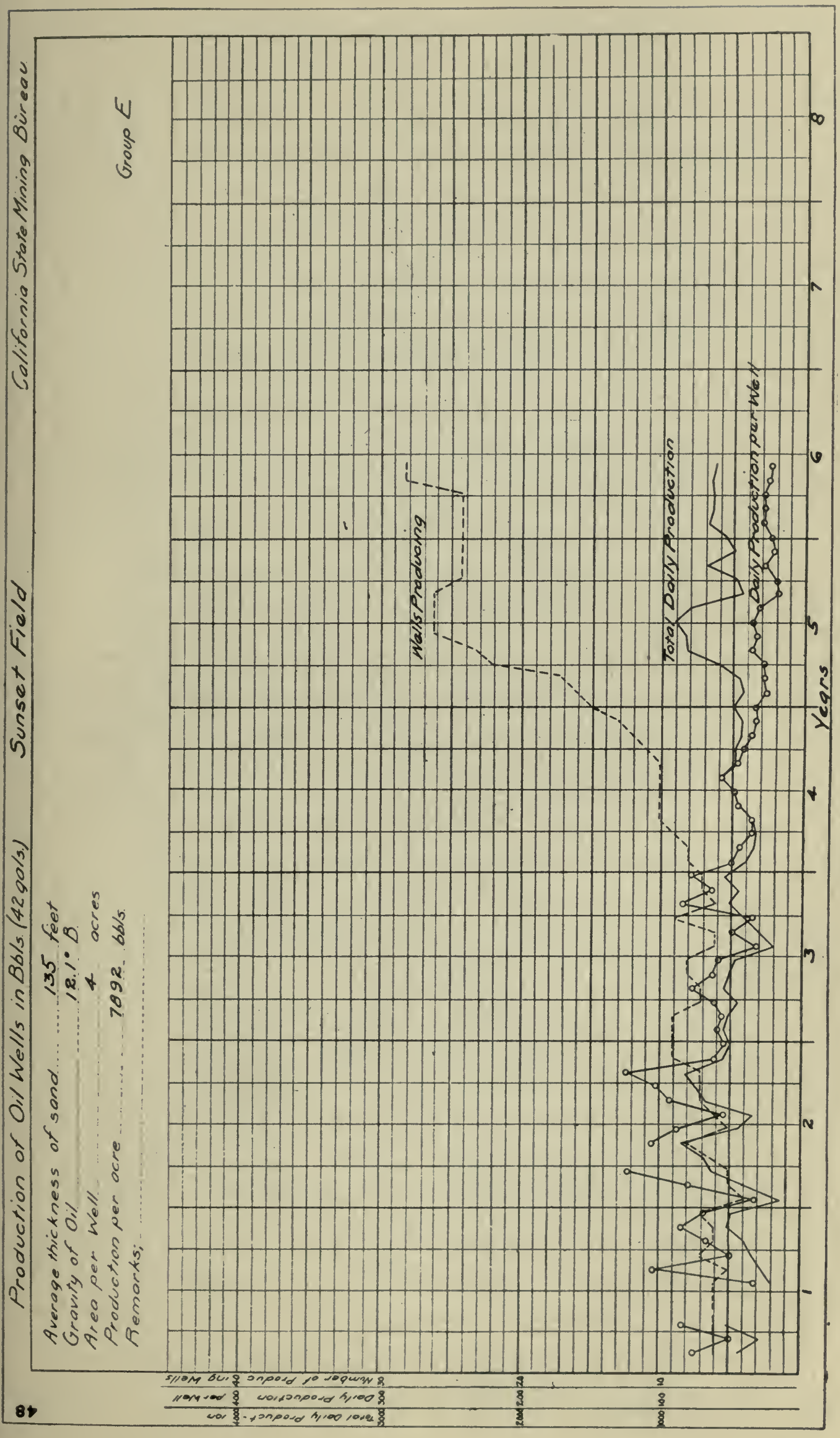


Fig. 48. Production record of 28 wells.

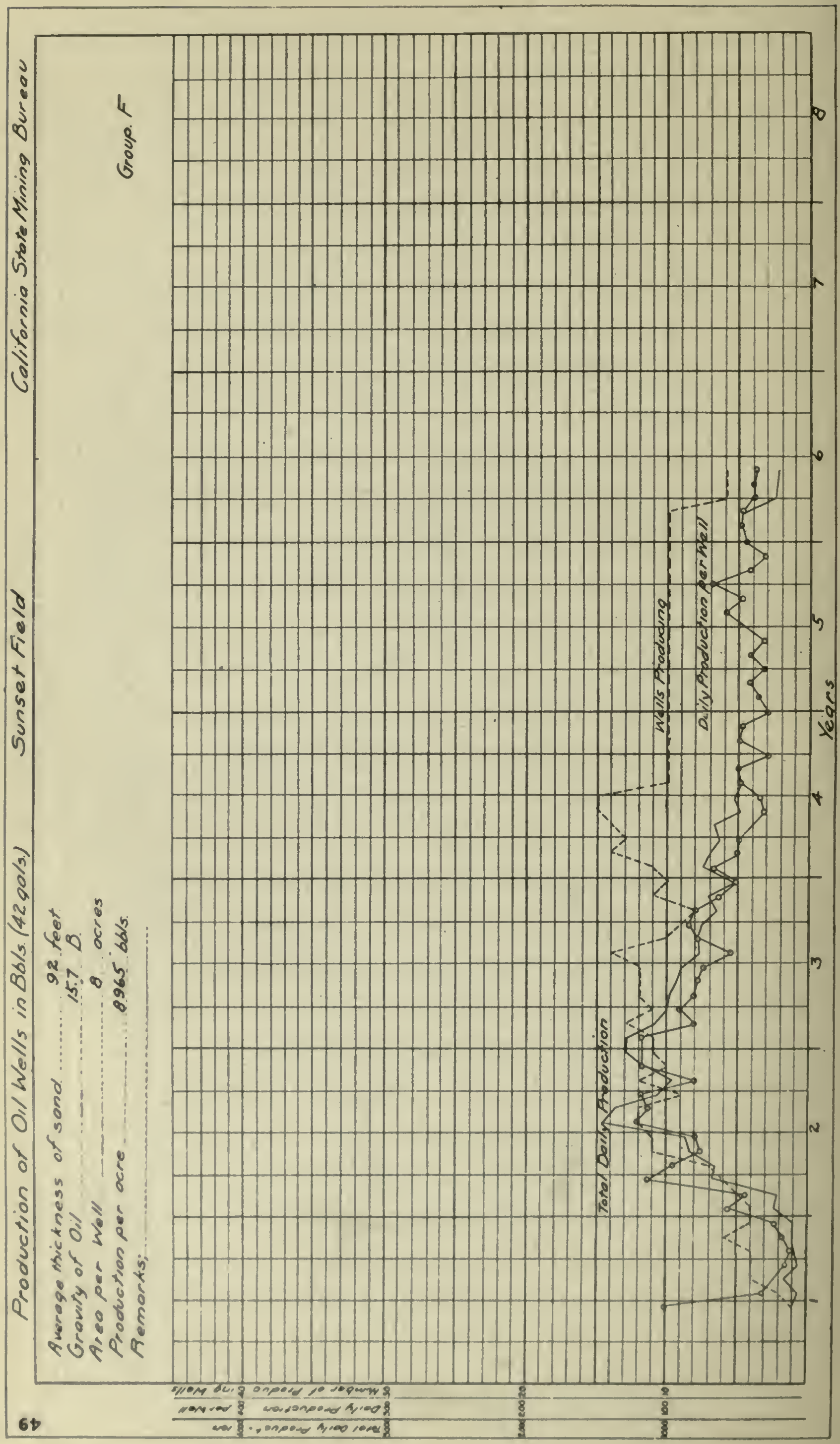


Fig. 49. Production record of 15 wells.

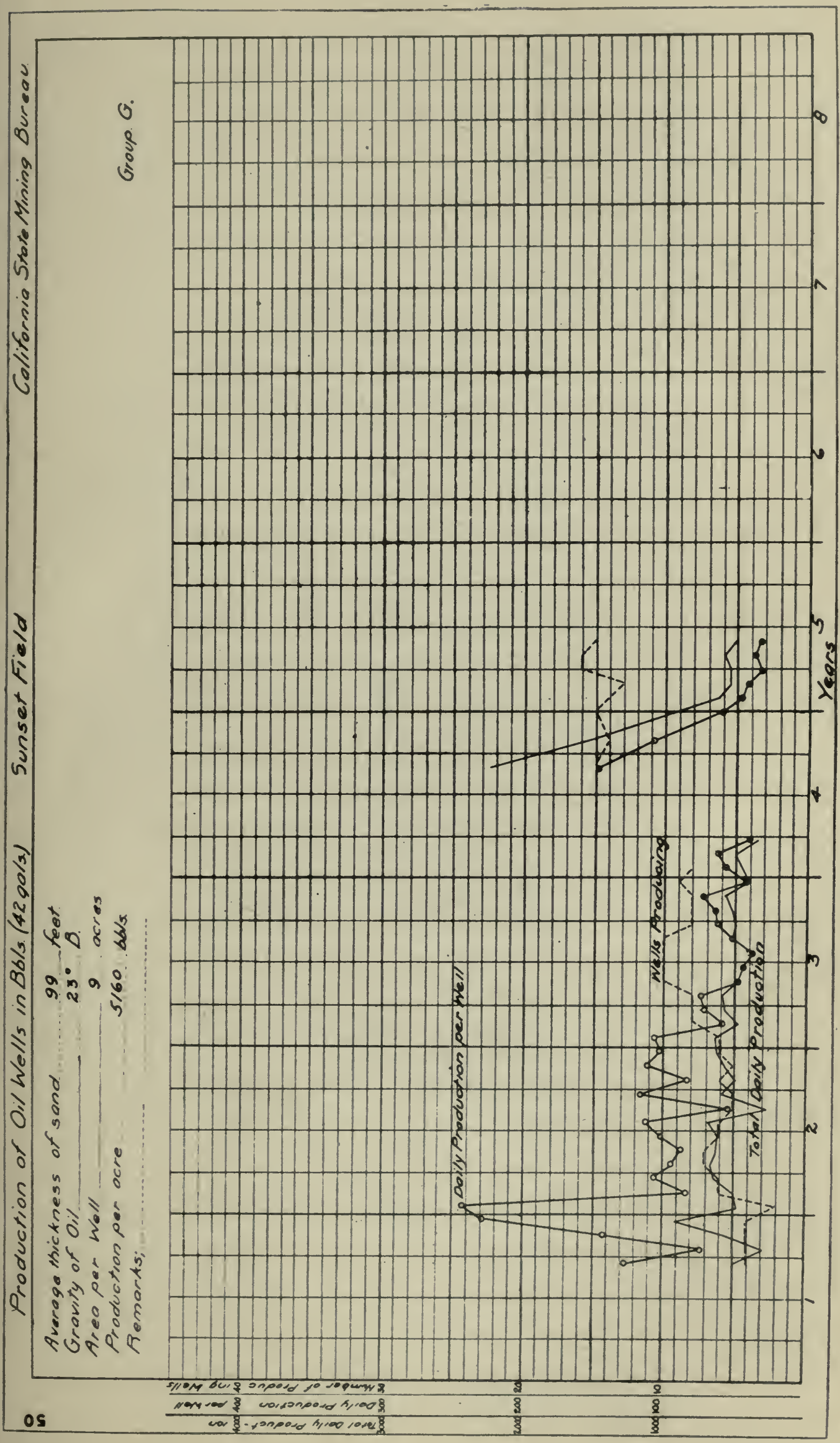


Fig. 50. Production record of 16 wells.

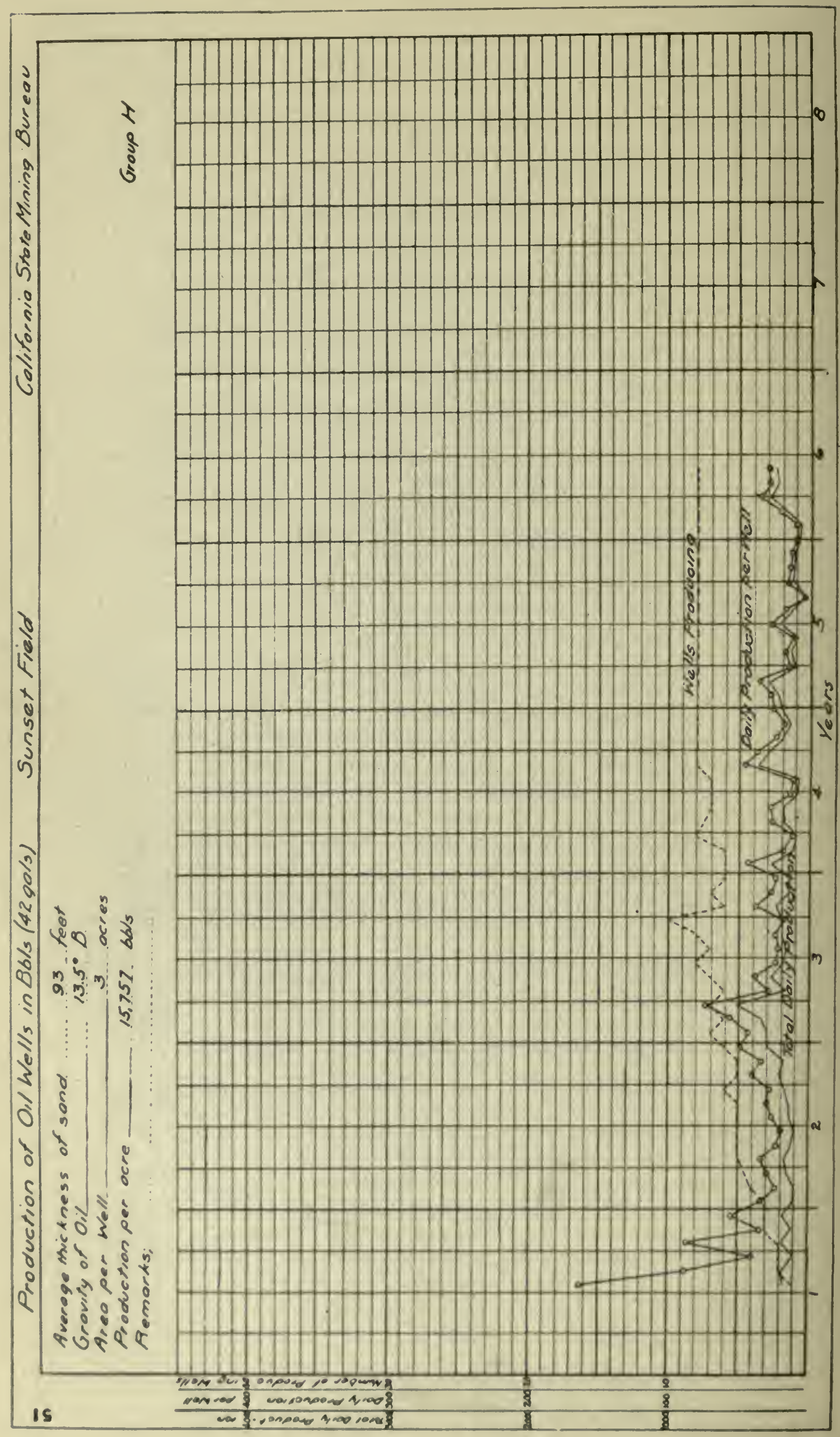


Fig. 51. Production record of 8 wells.

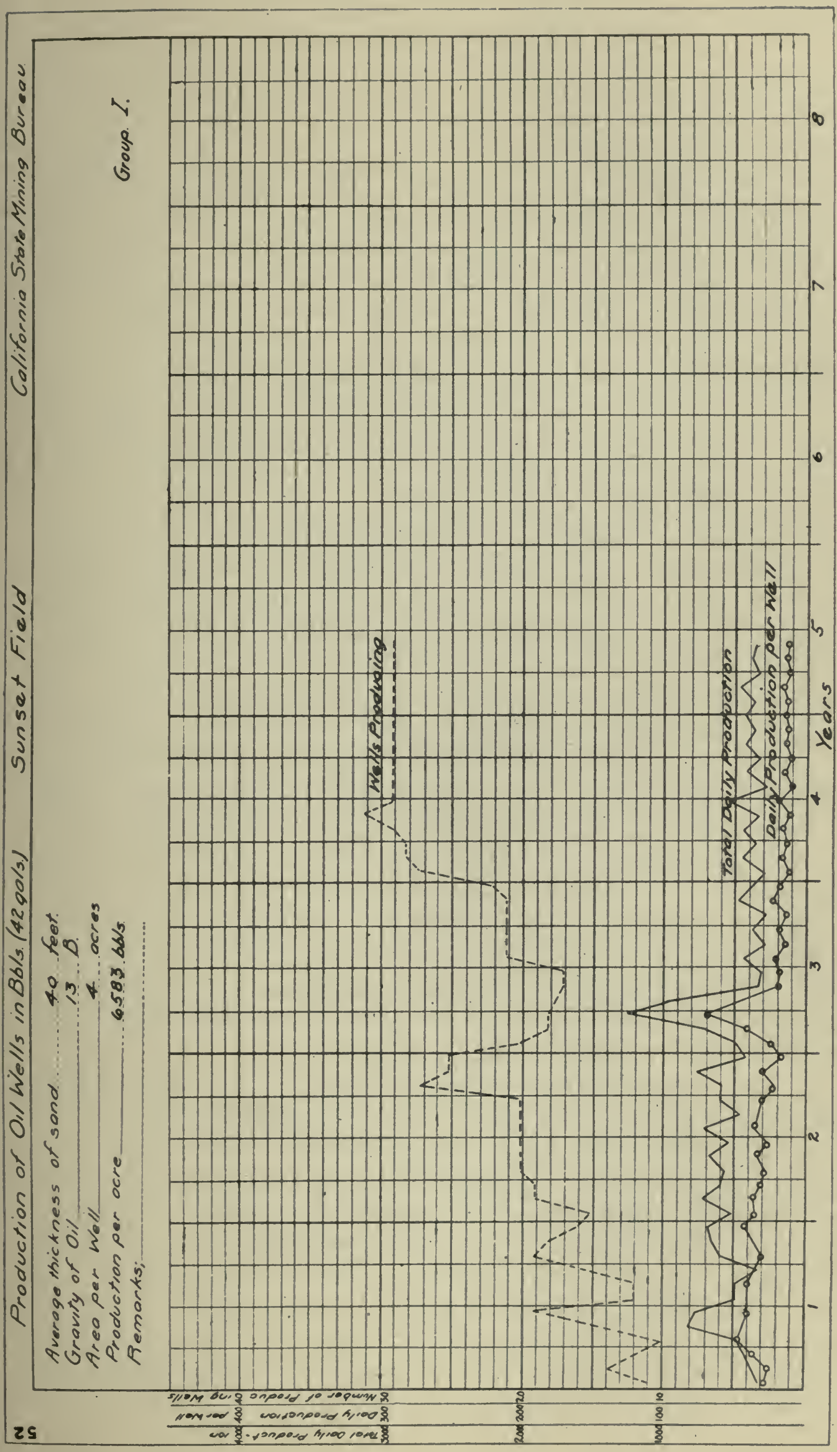


Fig. 52. Production record of 31 wells.

WATER CONDITIONS.

The water conditions in the Midway and Sunset fields were investigated early in 1914 and the following information was published in the form of a preliminary report:

The total thickness of oil sands varies from twenty-five to two hundred feet. They exist in the form of rather flat non-continuous bodies, or lenses, most of which lie in two well recognized zones, which are not parallel. Water is contained in similar sands both above and below those carrying oil. There are a number of folds in the underground formations, some of which are scarcely indicated on the surface. Underground conditions are not so simple as in the Coalinga Field nor so easily described. Some 1,600 wells have been completed, ranging in depth from 800 feet to over 4,000 feet. The cost of wells has been from $4,000 to $100,000 each. About one hundred and seventy companies own or operate property in the territory.

As was stated in the report on the Coalinga Field, water will enter the oil sands and entirely ruin a well and its neighbors unless the several strings of casing are placed securely, and in their proper position. It can not be too forcibly emphasized that the work of protecting oil sands from water consists of two distinct branches as follows: The casing must be landed securely, and frequently cemented, by a thoroughly skilled and experienced driller. It also must be landed in the proper place, which, in most cases, can only be determined by a thoroughly informed and experienced geologist or engineer. Attempting to systematically control underground water without the services of the geologist-engineer is as absurd as sending a vessel to sea without a navigator.

The two branches of work are being carried on in these fields. Description of methods and conditions are as follows:

The work of protecting the oil sands is carried on by two separate and distinct concerns, namely the county government, and a semi-public association of oil operators.

For several years the position of County Oil Well Commissioner has been occupied by a driller, who has had a great deal of experience and bears a reputation of being a thorough workman. The Commissioner willingly assisted the State Mining Bureau in its inquiry. During the past two years he has participated in the work of shutting off water at 156 wells. Existing legal methods controlling this position do not provide for a complete file of records and further information as to the exact nature of the work is not at hand.

The Kern County Oil Protective Association was formed in March, 1912, and consists of some forty companies who make monthly payments for its support. Over 75 per cent of total receipts are from seven large companies who produce about 60 per cent of total oil, own about 64 per cent of the proved land and 36 per cent of the completed wells. A business office is maintained at Bakersfield, but all the detail and statistical work is done at the Taft office. There is a geologist and one assistant at the Taft office, which is also used as headquarters for the County Oil Well Commissioner. According to its published report to subscribers, dated September 15, 1913, the association aims to give advice to operators, aiding them in shutting off water, "and prepare and endeavor to have passed an adequate law to protect the fields of the state from the infiltration of water." The report further explains as follows:

"A daily record is kept by the field force of the properties visited by them, and a detailed report is furnished the executive committee each month, going fully into the work of the previous month.

"The report for the month of August gives an account of the work of thirty-three companies, and the progress they are making in shutting off water in their wells. An inestimable amount of assistance was rendered these companies, most of whom are not in a position to hire experts for this work and gladly avail themselves of the valuable and reliable service the Commission is able to give them.

"These properties were visited by the Commissioner, or his assistants, from one to ten times during the month. A copy of the monthly report is on file in this and the Taft offices, and any member of the executive committee will be pleased to go over the report with any subscriber.

"We earnestly urge every company to instruct their field superintendent, or other representative, to visit the office in Taft and advise with the Commissioner or his deputies in regard to water conditions in either new or old wells. Logs and cross-sections will be gladly furnished without cost to any company, of their own property or of an adjoining property, when necessary and with the consent of the owner thereof.

"It is not possible to shut off the water in all the wells now drilled, but with the cooperation of all the producers on the West Side *it is possible to drill the new wells and finish them with the water absolutely shut off*.

"The best results can be obtained, in treating any water trouble, only when all possible information can be had from neighboring wells. Will you, therefore, kindly furnish the association with copies of the logs of your wells if you have not already done so? Any information that you regard as confidential will be strictly treated as such and will be used only in reaching conclusions by the Water Commissioner and assistants."

The cost of the Taft office, including rent, automobile operation and salaries of the geologist and assistant, is approximately $6,000 per year.

The information obtained from the Taft office of the association was more systematic and complete than that obtained by other inquiries in the fields. Records, however, showing the amount of water coming from various wells and properties were not on file to the extent found in the office of the Oil Well Commissioner at Coalinga and a direct statistical comparison of water conditions in the two districts is therefore impossible. Detailed inquiry leads to the conclusion that the older portions of the Sunset-Midway field are in almost as serious a condition as is the Coalinga Field. It is possible to enumerate even with incomplete data about one hundred wells which are making over 10 per cent water. This is a considerably lower proportion than in Coalinga, but on the other hand during the past year and a half, about twenty wells have been abandoned in the Midway-Sunset field, largely on account of water. These abandoned wells represent a loss of probably a half million dollars.

The geologist of the association enumerated ten properties upon which repair work had been done on wells making water, twenty-eight of which are in course of remedying and twelve which are still doing damage that should be corrected.

An illustration of the result of drilling a well, without making use of all the information obtainable, occurred in the field while information for this report was being collected. A superintendent, who had previously finished several wells satisfactorily with advice from the association geologist, proceeded without advice and drilled another well too far through the oil sand and encountered a strong flow of water. This "bottom water" was actually encountered within two feet of where it had been expected by the geologist's study of logs of surrounding wells. Advice would have been to stop drilling some fifteen feet above the point to which it was carried. A contractor was engaged to cement the bottom of the hole after the flow of water had been checked by a "bridge." Providing the first cementing job is successful, the needless expense on this well will probably amount to about $500. The chief aim of the geologist of the association is to meet exactly such circumstances *in time to prevent trouble,* rather than aid in patching up improperly drilled wells which is, at best, apt to be troublesome and unsatisfactory. Large companies frequently have a competent cementing crew while the smaller operators usually call in one of the several successful contractors. Competent drillers and cement men are not scarce.

The greatest importance of systematic control of underground water is well illustrated in one particular portion of the Midway-Sunset field where several operators are being injured and the oil resources of the state ruthlessly wasted. There are two known oil sands, in this particular locality, both productive. There are water-bearing sands above the upper oil sand and also between the two oil sands. When a well is drilled into the lower sand two extra strings of casing (about 2,000 feet of 8-inch and 2,500 feet of 6-inch) should be inserted to keep the water out of the upper sand. The extra casing and labor may amount to $10,000 per well. Some operators have neglected or refused to drill their wells in this manner and have seriously damaged others whose wells are dependent upon the upper sand, because they are of too small diameter to allow deeper drilling.

An approximate idea of the ultimate loss that will ensue, unless the top sand is protected, may be gained from the following figures: A single well, at present producing, has during the past three and a half years produced almost 300,000 barrels of oil. Other wells though not so large should produce for a much longer time than three and a half years, and the figure is not an unreasonable one in assuming their total production. The upper sand extends over some 400 acres, and at five acres per well, should supply 80 wells, or a total of not less than twenty-four million barrels, or twelve million dollars.

Conclusions drawn from the observations in the Midway-Sunset and Coalinga oil fields are as follows:

(1) Technical information is absolutely necessary to efficiently develop a large oil field.

(2) The present rate of development and the size of these two fields (Midway-Sunset and Coalinga) requires the constant attention of a man in each field.

(3) The technical information will probably be more generally accepted and used by operators if the man giving it out is a public official empowered to obtain logs or other data of all wells.

(4) Legislation is doubtless necessary, to prevent some operators from damaging neighboring property, and to repair damaging wells owned by defunct or financially embarrassed concerns.

(5) Power to order repairs or abandonment of wells should not be lodged in the hands of a single individual.

McKITTRICK FIELD.

LOCATION.

The McKittrick Field is situated in Kern County, about five miles northwest of the Midway Field, in T. 30 S., R. 21 E. and T. 30 S., R. 22 E.

Climate, topography and general appearance of the field is similar to conditions in the Midway Field.

The Southern Pacific branch railroad from Bakersfield has operated since 1893 and the field is also served by three pipe lines.

GEOLOGY.

The examination and description made by the U. S. Geological Survey in 1908 (Bul. 406, pp. 111–142) is considered ample as later developments have failed to extend the proved area; in fact, as that term is defined in this publication the proved area is less than stated in the survey report. The abandoned wells plotted on our map show the unsuccessful efforts that have been made to extend the field, particularly north and northeast.

Briefly stated, the important geologic formations exposed are Monterey and Etchegoin.

The Monterey is largely diatomaceaus shale and readily distinguished from the overlying coarse Etchegoin sands. Names of the formations as here used are somewhat different from those used in other publications and the reader is referred to our description of the Midway Field.

The Etchegoin sands are the productive oil reservoirs and the productive areas are apparently largely governed by structure of the beds. There are several very sharp folds, in some places accompanied by faulting.

HISTORY OF DEVELOPMENT.

The McKittrick Field was the scene of activity early in the history of California. In 1866 the Buena Vista Petroleum Company held claims covering a considerable portion of the present proved area. Most of the development seems to have been either shafts or open cuts in or near the oil outcrops. A refinery was erected and three or four thousand gallons of refined oil (probably heavy distillate) was produced, besides asphaltum. Some of the products were hauled to San Luis Obispo and shipped by water to San Francisco, but with freight rates from $75 to $90 per ton, and other difficulties equal, it is not surprising that work soon ceased. (Fourth Annual Report, State Mineralogist, p. 297.)

Some time between 1884 and 1887 a well was drilled by Blodgett & Weill on the SE. ¼ of Sec. 13, T. 30 S., R. 21 E. Oil raised about one hundred feet in the pipe but the well was never pumped.

In 1887 Mr. J. S. Hambleton drilled a well more than 500 feet deep and encountered oil (Seventh Annual Report, State Mineralogist, p. 67).

In 1892 the railroad from Bakersfield to Olig was constructed and from that time until about 1900 the Standard Asphalt Company operated a 60-ton refinery.

In 1900 there were sixteen producing wells and seven drilling (Bulletin 19, California State Mining Bureau, p. 128).

Subsequent development and production is best illustrated by the statistical table and diagram accompanying this publication and the directory of companies.

The large holdings of the Associated Oil Company, in this field, were acquired at the time of that company's organization about 1901, when the marketing of the heavy oil being produced was a serious problem. Its use as fuel had not yet become general and many small operators turned their properties over to the larger concern.

As before stated, efforts to enlarge the field have been numerous. The most recent activity, about 1908, was about two miles to the northeast in the region commonly referred to as the "McKittrick Front."

Some of the outlying wells drilled and reported results are as follows:

Name	Location	Result
Leader	W. ½ SW. ¼, Sec. 35, 29-21, 3,200′	Oil.
S. & W.	Sec. 26, 29-21, 1,300′	Some oil.
Globe (Union)	Sec. 9, 29-21, 2,620′	Some gas.
Successus	Sec. 26, 29-21, 1,200′	Heavy oil.
Arcadia	S. ½ Sec. 26, 29-21, 1,020′	(?)
Oakland-McKittrick	Sec. 25, 29-21, 1,300′	
General Petroleum	Sec. 15, 29-21, 1,800′	Incomplete.
Mahaska	Sec. 35, 29-21,	Heavy oil.
Springfield	Sec. 29, 29-21, 1,380′	
Temblor	Sec. 32, 29-21, 2,191′	No oil.
Whittier	Sec. 4, 29-21, 863′	Showing.
Union	Sec. 18, 29-22, 4,000′	No oil.
Anglo-American	Sec. 18, 29-22, 1,160′	
Fearless	Sec. 16, 30-22, 1,000′	Abandoned.
United States	Sec. 6, 30-22, 1,200′	Gas.
United States	Sec. 16, 30-22,	Heavy oil.
Union	Sec. 4, 30-22, 3,569′	No oil. Gas.
Newman & Morris	Sec. 26, 30-22, 1,620′	Showing.
Nacerima	Sec. 6, 30-22, 950′	Some 12° oil. (?)

Future work, therefore, may be expected to develop some outlying "pools" of heavy oil. Deeper drilling in the developed field is a subject upon which sufficient data are not here available, but it should be thoroughly considered.

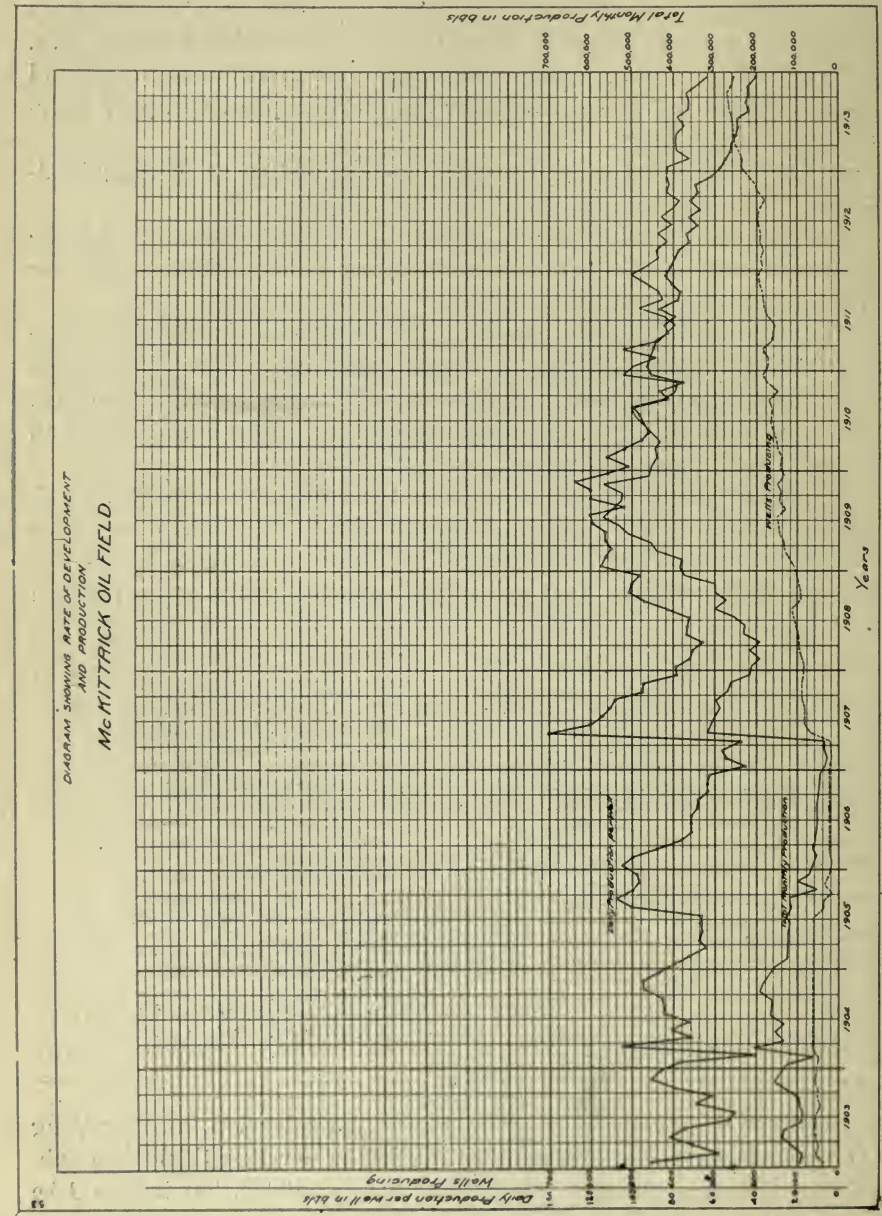


DIAGRAM SHOWING RATE OF DEVELOPMENT
AND PRODUCTION
McKITTRICK OIL FIELD.
Total Monthly Production in bbls
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
Years
Daily Production per well
Total Monthly Production
Wells Producing
Wells Producing
Daily Production per well in bbls
80
60
40
20
0

Fig. 53.

History of development of the McKittrick Field since 1903 is shown by the accompanying diagram (Fig. 53) based on figures furnished by the Standard Oil Company. Earlier figures in detail are not available. The field is remarkable for its great production from a small area.

1903 to 1906.—There was but little new work carried on during this period. The number of producing wells varying from time to time between 25 and 65, with an average daily production from 60 to 100 barrels, giving a monthly total of from 50,000 to 200,000 barrels.

1907 to 1913.—About the middle of 1907 drilling new wells began and has been uniformly continued, increasing the number of producers at the rate of about 29 per year. Coincident with the drilling activity the total monthly production increased to a maximum of about 572,000 barrels in November, 1909, and has since gradually declined to 317,000.

Decline in well production has been fairly uniform since the middle of 1909 (116 to 40), or 16 barrels per year. The future of the field may be fairly surmised as the limits of productive land have been quite definitely established.

The rate of decline in well production, down to December, 1913, if continued, would in two years reduce the yield per well to about ten barrels per day, below which it will be difficult if not impossible to operate. Water is a serious problem, being at present handled by compressors, along with the oil, at a number of wells. Of course two years more is not apt to reduce all of the wells in the field to ten barrels, but twice that length of time will possibly see many of the present producing wells suspended. The figures for 1914 show a slackening, in the rate of decline, which would of course greatly lengthen the time estimate.

The proved area is about 1.4 square miles which with 270 producing wells gives 3.3 acres per well. The total production since 1903 is 37,103,169 barrels, or 41,450 barrels per acre.

STATISTICS OF FIELD DEVELOPMENT.

(Standard Oil Company.)

McKittrick Field.

Year	Wells producing	Number of wells completed during month	Monthly production	Barrels per well per day
1903				
January	32	----------	93,000	93
February	54	----------	89,600	59
March	49	----------	108,500	71
April	55	----------	136,050	82
May	57	----------	132,600	75
June	56	----------	91,530	54
July	55	----------	87,638	51
August	44	----------	94,085	69
September	52	----------	93,540	62
October	50	----------	124,403	80
November	57	----------	156,660	91
December	53	----------	142,600	87
Total	----------	----------	1,353,206	
1904				
January	53	----------	127,000	77
February	48	----------	58,000	41
March	63	----------	204,445	105
April	62	----------	135,000	72
May	62	----------	155,000	81
June	62	----------	135,000	73
July	63	----------	165,540	85
August	63	----------	165,540	85
September	63	----------	162,000	86
October	65	----------	192,200	95
November	65	----------	186,000	95
December	63	----------	170,500	87
Total	----------	----------	1,856,225	
1905				
January	62	----------	155,000	80
February	62	----------	126,000	73
March	62	----------	124,000	65
April	60	----------	123,000	68
May	60	----------	124,000	67
June	60	----------	120,000	67
July	61	----------	127,100	67
August	38	----------	119,600	101
September	38	----------	123,750	108
October	18	----------	55,950	100
November	35	----------	102,000	97
December	24	----------	72,630	98
Total	----------	----------	1,373,030	
1906				
January	20	----------	65,100	105
February	20	----------	56,000	100
March	25	----------	68,200	88
April	26	----------	60,000	77
May	26	----------	58,000	72
June	26	----------	56,130	72
July	26	----------	58,001	72
August	26	----------	55,800	69
September	26	----------	54,000	69
October	26	----------	51,925	64
November	25	----------	48,000	64
December	25	----------	49,600	63
Total	----------	----------	680,756	

McKittrick Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production	Barrels per well per day
1907				
January	25	-----	35,650	46
February	20	-----	30,800	55
March	21	-----	37,200	57
April	25	-----	36,000	48
May	73	-----	320,850	141
June	86	-----	312,500	121
July	85	-----	302,250	115
August	84	1	290,200	111
September	92	1	299,250	109
October	92	1	270,475	95
November	92	3	263,300	95
December	89	2	217,365	79
Totals	-----	8	2,415,840	
1908				
January	87	1	213,550	79
February	91	4	192,995	73
March	97	3	215,455	72
April	98	4	193,500	66
May	100	5	231,240	74
June	104	8	229,800	74
July	112	2	253,620	73
August	116	6	300,800	83
September	94	2	272,800	97
October	94	12	298,270	102
November	99	4	299,500	101
December	103	15	374,770	97
Totals	-----	66	3,076,300	
1909				
January	109	9	388,695	115
February	121	7	382,840	113
March	131	4	446,090	110
April	135	11	457,710	113
May	147	2	516,119	113
June	149	6	534,150	119
July	153	3	571,910	120
August	130	2	420,270	104
September	147	1	529,500	120
October	142	5	529,070	120
November	150	5	572,660	127
December	134	4	461,346	111
Totals	-----	59	5,810,360	
1910				
January	144	6	457,352	102
February	142	7	445,372	112
March	151	5	448,402	103
April	153	4	435,420	95
May	160	7	456,750	92
June	168	8	474,505	94
July	168	2	499,785	96
August	166	2	508,373	99
September	174	3	425,715	82
October	150	2	398,939	86
November	174	7	395,366	75
December	189	1	525,634	90
Totals	-----	54	5,471,613	

McKittrick Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production	Barrels per well per day
1911				
January	175		499,580	92
February	174	4	444,370	91
March	189		524,719	89
April	165	4	438,984	88
May	163	2	416,378	82
June	159	2	399,620	84
July	174	1	424,690	79
August	183	4	485,887	86
September	186	5	428,107	77
October	187	4	439,420	76
November	195	4	470,346	80
December	197	6	505,431	83
Totals		36	5,477,532	
1912				
January	188	3	470,610	81
February	191	2	439,059	79
March	186		444,291	77
April	195	1	419,391	72
May	193	5	440,694	73
June	197	2	403,674	68
July	200	1	433,972	70
August	194	2	402,402	67
September	182		389,600	71
October	198	2	418,132	68
November	204	1	412,636	67
December	222	1	419,974	61
Totals		20	5,094,465	
1913				
January	236	1	416,418	57
February	234	1	361,505	55
March	241	3	394,170	52
April	252	1	397,182	52
May	254	1	395,643	50
June	257	1	376,933	49
July	260	5	393,521	49
August	267	4	365,181	44
September	269	1	364,092	45
October	271		371,827	44
November	260		343,031	44
December	254		317,339	40
Totals		18	4,496,842	
Total completed		261		
Idle or abandoned		39		
1914				
January	254		317,347	40
February	267		304,500	41
March	268		335,482	40
April	266		322,200	40
May	221	1	285,200	42
June	250	2	292,230	39
July	269	2	346,797	41
August	274	1	359,507	42
September	263	2	323,520	41
October	270		320,292	38
November				
December				
Totals				

FINANCIAL RESULTS.

Financial results in the McKittrick, Belridge and Lost Hills fields combined during the year 1913, as shown by fourteen companies, producing 5,316,697 barrels of oil from 177 wells, are summarized as follows:

Capital. This figure can not be definitely determined, particularly the second item (property value) and any error here is apt to be on the side of an overestimate.

Cash paid for stock	$794,859 00
Property paid for stock	8,164,292 00
Total	$8,959,151 00

Dividends are difficult to determine as many concerns are close corporations, making no public reports, hence our figures may be slightly below the actual amounts. Records earlier than 1909 were not available:

1909, 2 companies	$269,795 00
1910, 2 companies	239,750 00
1911, 1 company	85,000 00
1912, 2 companies	134,945 00
1913, 6 companies	538,744 00
	$1,268,234 00

The dividend paying companies produced 1,935,000 barrels of oil, 20 per cent of the field total. Three companies produced oil as low as 14° Baumé. Other facts are tabulated on page 10.

Business conditions of the McKittrick District during 1912, based on the operations of ten companies, from 44 producing wells 1,388,158 barrels were yielded.

The total operating expense (not including depreciation, taxes, insurance, and interest, which are here referred to as fixed charges) was $200,929, averaging $12.44 per well, or 14.5 cents per barrel. These figures include costs on wells drilling, of which there were four.

DIRECTORY OF COMPANIES OPERATING IN McKITTRICK FIELD.

Company	Location	Wells completed	Gravity	Official address
*American Oil Fields	4-30-22	--------	--------	Security Bldg., Los Angeles.
Argue	36-29-20			
Arcadia	26-29-21			
Associated Oil Co.	11-30-21	8	--------	Sharon Bldg., San Francisco.
Associated Oil Co.	13-30-21	4		
Associated Oil Co.	19-30-22	1		
Associated Oil Co.	13-30-21	32		
Associated Oil Co.	18-30-22	6		
Associated Oil Co.	19-30-22	14		
Associated Oil Co.	12-30-21	1		
Associated Oil Co.	13-30-21	4		
Associated Oil Co.	20-30-22	6		
Associated Oil Co.	19-30-22	7		
Associated Oil Co.	20-30-22	1		
Blue Grass	14-31-21			
Brown	26-30-22			
Burns	8-30-22			
*C. J. (Berry & Keller)	11-30-21	1	16.0	
C. J. (Berry & Keller)	13-30-21	15		
*California King	36-29-20	4	--------	Citizens National Bank Bldg., Los Angeles.
Temblor	3-29-19	--------	--------	Citizens National Bank Bldg., Los Angeles.
Carolina	10-30-21			
Common Sense	31-29-21			
*Cousins	18-30-22			
Cox	15-31-21			
*Dillon	36-29-20	3	15.5	
*East Puente	11-30-21	11	14.2	635 Fifth st., San Diego.
Elliott	31-29-21	--------	--------	323 Storey Bldg., Los Angeles.
Everett	2-30-21			
Fairfield	19-30-22	5	15.2	308 Columbia Trust Bldg., Los Angeles.
Fearless	16-30-22	--------	--------	60 California st., San Francisco.
*Globe	36-29-21	--------	--------	616 Union Oil Bldg., Los Angeles.
Humauma	35-31-21			
I X L	18-30-22	--------	--------	343 Citizens National Bank Bldg., Los Angeles.
*I. O. P. A.	18-30-22			
*Jewett	13-30-21	10	14.6	Bakersfield.
*Jackson	2-30-21	1	14.0	McKittrick.
Jackson	11-30-21	1		
Kern River	13-30-21	4	14.5	350 Mills Bldg., San Francisco.
Kern Trading and Oil	13-30-21	40	15.0	Flood Bldg., San Francisco.
Kern Trading and Oil	20-30-22	8	18.0	
Kimble	3-30-22			
Los Angeles-McKittrick	29-29-21			
Leader	35-29-21	--------	--------	McKittrick.
*Madison (Yellowstone)	11-30-21	1		
*Merrill & Vegas	10-30-21			
*Mahaska	36-29-21	1	11.6	
McKittrick Investors	11-30-21			
McKittrick Operators	10-30-21	--------	--------	434 Douglas Bldg., Los Angeles.
McKittrick Extension	18-30-22	--------	--------	Bakersfield.
McKittrick Oil	12-30-21	--------	--------	Bakersfield.
McKittrick Oil	18-30-22	2	--------	Bakersfield.
Miners	31-29-21			
Monarch	34-30-22	1	--------	1931 Chester ave., Bakersfield.
Nacrimena	6-30-22	1	--------	622 Security Bldg., Los Angeles.
Newman & Morris	26-30-22			
*Olig Crude	13-30-21	5	15.6	109 N. Main st., Los Angeles.
Oakland-McKittrick	6-30-22	--------	--------	1603 Brush st., Oakland.
Providence (Mid Royal)	29-30-22	8	--------	404 Auditorium Bldg., Los Angeles.
Petroleum Products	32-31-22			
Quimby Bros.	6-31-21	1		
Research	34-29-21			
Result	2-30-21			

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*Member Independent Oil Producers' Agency.

Companies Operating in McKittrick Field—Continued.

Company	Location	Wells completed	Gravity	Official address
Reward	11–30–21	13	15.0	280 Battery st., San Francisco.
Reward	13–30–21	23	--------	280 Battery st., San Francisco.
State	19–30–22	13	15.6	149 California st., San Francisco.
*San Francisco-McKittrick	14–30–21	17	16.0	607 Monadnock Bldg., San Francisco.
*Shear Petroleum	36–29–20	2	15.5	
Sans Souci	18–30–22			
Shale Basin	29–30–22			
Sea Breeze	6–30–22	--------	--------	Box 246, Bakersfield.
St. Joe	25–29–20			
Sunshine	25–29–20			
S. & W.	26–29–21	1		
Success	26–29–21	1	--------	109 N. Main st., Los Angeles.
Temblor-McKittrick	34–30–22	2		
*Temblor Ranch	36–29–20	8	15.4	
Twenty	20–30–22	1		
Traction	24–31–21			
*U. S. Oil and Mining	6–30–22	3	11.6	Box 246, Bakersfield.
Union	4–30–22	--------	--------	Union Oil Bldg., Los Angeles.
Union	32–29–22			
Virginia	20–30–22	--------	--------	Security Bldg., Los Angeles.
Williams & Ball	2–30–21			
*Warren	36–29–20			
Total	----------	291		

*Member Independent Oil Producers' Agency.

Amount of oil produced during 1913 by the various companies is indicated by figures on pages 39, 42, 44.

PRODUCTION COST.

Production cost in the McKittrick Field is shown by the following figures of a representative property, which produces about 75 barrels per well per day.

Costs are increased due to water which is frequently handled by air compressors, with the oil (see Kern River, page 213).

Pumping wells	$2 16 per well day
Repairing wells	1 60 per well day
Cleaning wells	26 per well day
Redrilling wells	52 per well day
Handling oil	95 per well day
Miscellaneous	62 per well day
Superintendence	49 per well day
Total	$6 60 per well day

The quality of oil in the McKittrick Field is fairly uniform, being about 15° Baumé, except the group of wells in and very near Section 20, T. 30 S., R. 22 E., where the gravity is as high as 18° or 19° Baumé.

LOST HILLS—BELRIDGE AND DEVIL'S DEN REGION.

LOCATION.

These districts (see Plate XII) lie in the western part of Kern County, in a northwest-southeast extent of territory, about twelve miles wide, having as its southwestern boundary, the base of the Temblor range, and situated between the northern line of T. 25 S. and the southern line of T. 29 S.

The climate and general appearance of the country is similar to that of the Coalinga and Midway fields.

The topography is level with only a few low rounded ridges. In looking across the country it appears to be an unbroken plain. The ridges are indicated on the map, they probably indicate anticlinal structure and are the most important natural feature of the region.

GEOLOGY.

Surface study reveals but little as to the geology except along the base of the Temblor range. A description and map of this area is included in Bulletin 406, U. S. Geological Survey.

The areas of shale, shown as Monterey and Santa Margarita, are the most notable outcrops of rocks in place. As noted in our description of the Midway Field (page 228), the shale is possibly all of Monterey age. Upon the flat lands principally alluvial deposits containing many shale pebbles are seen.

There are outcrops of oil-bearing sands at Gould Hills, Sec. 7, 29–21, and near the Belridge wells, Sec. 33, 28–21. Both of these occurrences are in the formation overlying the Monterey shales and are probably of Etchegoin age, from which all the oil in these districts is produced. Other outcrops are located as follows: NW. ¼ Sec. 33, T. 28 S., R. 20 E.; E. ½ Sec. 3, T. 29 S., R. 20 E. In the Lost Hills outcrops scarcely recognized as oil sands occur at NW. ¼ Sec. 3, NE. ¼ Sec. 24, T. 26 S., R. 20 E.

Early observers based statements, as to oil possibilities of the Lost Hills region, upon the assumption that formations below the shale were the principal reservoirs. (Bulletin 406, U. S. Geological Survey. page 206.) Drilling has proved the sands above the shale to be very productive. Sands containing oil and lying below the shale do outcrop in the Devil's Den region but are as yet unproductive, and also at Temblor, Sec. 36, T. 29 S., R. 20 E., where for many years (1900 or earlier), the Temblor Ranch Oil Company has produced oil of about 15° Baumé. Initial discoveries at Lost Hills and Belridge have principally been due to efforts of prospectors without geologic knowledge, although subsequent development work has been most effective where geologic knowledge has also been applied. The early geologic work of Mr. W. A. Williams has been particularly useful in this region.

The first discovery of importance was the Martin & Dudley well in the Lost Hills (Sec. 30, T. 26 S., R. 21 E.) in the summer of 1910, oil being struck at a depth of 472 feet. Many other wells were drilled shortly afterward and proved a narrow strip of land along the low ridge. Considerable drilling at a distance from the hills has failed to produce oil. The cross-section accompanying the map shows what seems to be a reasonable explanation of underground conditions.

Fossils thrown from some wells afford a very reliable basis for classification of the oil sand as Etchegoin.

Developments in the Belridge District began during 1911 near the outcropping oil sand which had escaped the notice of most observers. As indicated by the map a considerable number of producing wells have been drilled, proving a strip of land a fourth to a half a mile wide and nearly three miles long. Producing wells are from 800 feet to 1,000 feet deep, penetrating from 25 feet to 50 feet of oil sand. The oil is of good grade, being about 17° to 26° Baumé.

A number of outside wells have been unsuccessful, indicating conditions similar to those existing in the Lost Hills.

Name	Location	Depth	Result
Standard Oil Co.	Sec. 25, 28–20	2,500′	
Standard Oil Co.	Sec. 19, 28–21	4,085′	Little oil.
Standard Oil Co.	Sec. 25, 28–21	3,850′	
Standard Oil Co.	Sec. 23, 28–20	3,450′	
Union Oil Co.	Sec. 9, 29–21	3,890′	Little gas.
Union Oil Co.	Sec. 18, 29–22	3,940′	
Union Oil Co.	Sec. 20, 27–22	3,010′	
Reward	Sec. 1, 29–21	1,230′	Little heavy oil.
Juanita	Sec. 1, 29–20	3,050′	Little oil, 900 to 1,200.
General Petroleum	Sec. 2, 29–21	1,252′	Little oil.
Belridge and Associated Oil	Sec. 27, 27–20	3,490′	
Belridge and Associated Oil	Sec. 28, 27–21	2,840′	
Dominion Belridge	Sec. 9, 28–20		
Kern Petroleum (2 wells)	Sec. 13, 28–19	1,800′	
Roberts	Sec. 33, 28–20	1,200′	
Kimble	Sec. 33, 28–20	2,500′	Brown shale; no production.

A number of these wells entered brown shale at comparatively shallow depths and did not pass through it.

Three successful wells have been drilled in the southern portion of Sec. 35, T. 27 S., R. 20 E., by the Mannel–Minor Company, which indicate some possibilities of productive spots along the southern part of the Antelope Hills. The northern part of the hills is of doubtful value as the shale is very near the surface.

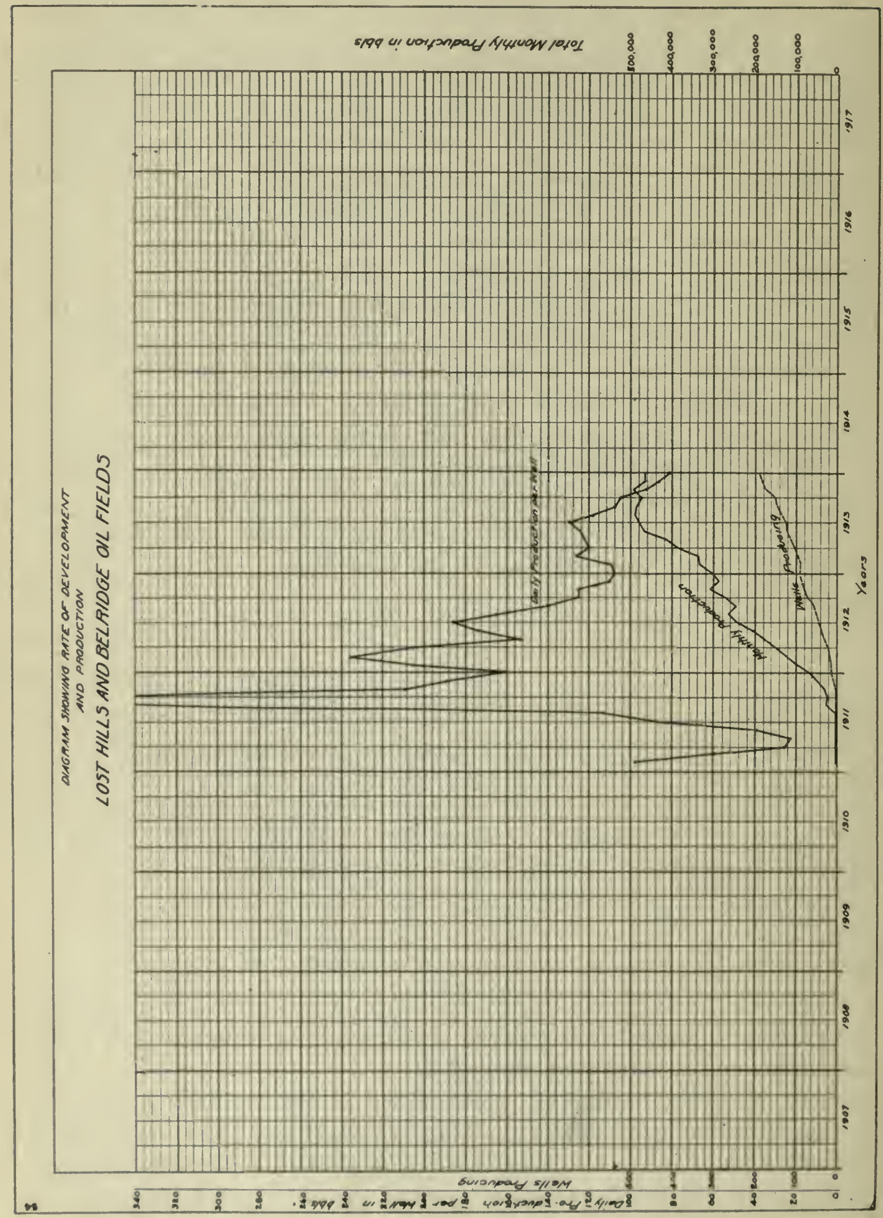


DIAGRAM SHOWING RATE OF DEVELOPMENT AND PRODUCTION
LOST HILLS AND BELRIDGE OIL FIELDS
Total Monthly Production in bbls
500,000
400,000
300,000
200,000
100,000
0
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
Years
Daily Production per Well
Monthly Production
Wells Producing
Daily Production per Well in bbls
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
600
400
300
200
100
0

Fig. 54.

Development work in the most promising portions of the Devil's Den region has been pursued for a number of years without a producing well. Among the notable prospect wells near Devil's Den are the following:

Name	Location	Depth
Cosmo Oil Co.	Sec. 31, 25-19	1,217′
Pluto Oil Co.	Sec. 19, 25-19	3,258′
Little Jack Oil Co.	Sec. 28, 25-18	2,247′
Lacey Oil Co.	Sec. 34, 25-18	1,980′
Marathon Oil Co.	Sec. 13, 25-18	1,705′

History of development and rate of production in the Lost Hills-Belridge District is shown by the diagram (Fig. 54) from figures by the Standard Oil Company. New work has gone forward continuously during 1912 and 1913 until there were 185 producing wells (85 per year); during the latter half of 1913 the monthly production remained between 400,000 and 500,000 barrels. Rate of production per well day has declined very fast, from about 200 barrels early in 1912 to about 80 barrels at the end of 1913. The record is too short to allow many general statements as to the future. It is probably safe to predict that the rate of decline in well production will be less rapid in the future, but the 1914 figures show that such a time has not yet arrived.

STATISTICS OF FIELD DEVELOPMENT.

(Standard Oil Company.)

Lost Hills-Belridge.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1911				
January	1	----------	3,000	97
February	1	1	1,650	59
March	1	----------	800	26
April	1	----------	700	23
May	1	----------	1,200	39
June	1	1	2,600	87
July	1	----------	3,500	113
August	3	----------	27,900	300
September	2	3	26,050	434
October	5	6	32,382	209
November	10	3	50,845	189
December	14	4	69,471	160
Totals	----------	18	220,098	
1912				
January	16	3	101,760	205
February	19	5	125,198	235
March	24	11	152,533	205
April	32	7	177,841	153
May	38	8	203,553	173
June	44	10	243,883	185
July	52	6	265,160	165
August	57	15	245,818	139
September	72	9	270,256	125
October	80	10	309,509	125
November	86	6	284,071	110
December	90	13	301,379	108
Totals	----------	103	2,680,961	
1913				
January	89	7	332,022	109
February	95	13	334,651	126
March	103	12	384,910	120
April	112	9	411,008	122
May	121	7	466,770	124
June	123	7	478,019	129
July	134	14	489,355	118
August	146	13	485,097	107
September	150	8	471,448	105
October	173	6	491,952	92
November	180	8	463,936	86
December	185	7	465,385	81
Totals	----------	111	5,274,553	
Total completed	----------	232	----------	
Idle or abandoned	----------	48	----------	
1914				
January	185	7	465,372	82
February	189	9	409,528	77
March	194	6	443,672	74
April	194	2	403,320	69
May	222	5	420,453	61
June	224	8	397,320	59
July	216	4	405,418	60
August	236	1	405,852	56
September	243	3	390,270	53
October	245	4	389,856	51
November	----------	----------	----------	
December	----------	----------	----------	
Totals	----------	----------	----------	

DIRECTORY OF COMPANIES OPERATING IN LOST HILLS AND BELRIDGE.

Company	Location	Wells completed	Gravity	Official address
Associated Oil Co.	29-26-21	9	--------	Sharon Bldg., San Francisco.
Belridge Oil Co.	28-28-21	72	--------	I. N. Van Nuys Bldg., Los Angeles.
Belridge Oil Co.	29-28-21			
Belridge Oil Co.	33-28-21			
Belridge Oil Co.	34-28-21			
Devil's Den Colsolidated	30-26-21	12		
General Petroleum Co.	3-29-21	23	--------	Higgins Bldg., Los Angeles.
General Petroleum Co.	2-29-21	3		
General Petroleum Co.	11-29-21	1		
General Petroleum Co.	4-27-21	16		
General Petroleum Co.	5-27-21	2		
Lost Hill Develop. Co.	19-26-21	5	--------	Lost Hills.
Lost Hill Develop. Co.	13-26-21	--------		
Mannell-Minor Oil Co.	35-27-20	3		
Standard Oil Co.	4-27-21	39		Standard Oil Bldg., San Francisco.
Standard Oil Co.	9-27-21			
Universal Oil Co.	30-26-21	38	--------	Crocker Bldg., San Francisco.
Universal Oil Co.	32-26-21			
Universal Oil Co.	5-27-21			
Vulcan Oil Co.	5-27-21	10		
Total	----------	233		

Amount of oil produced during 1913 by the various companies is indicated by figures on pages 31, 35, 42.

OIL PRODUCTION AND PRICE.

Kern County.

(McKittrick, Midway, Sunset, Kern River and Lost Hills-Belridge Fields.)

Year	Barrels	Price per barrel
1894	11,215	$6 16
1895	116	1 00
1896	235	1 00
1897	----------	----
1898	10	1 00
1899	15	90
1900	919,275	90
1901	3,902,125	29
1902	9,777,948	20
1903	18,001,148	20
1904	19,608,045	18
1905	17,069,715	19
1906	13,826,000	27
1907	15,700,308	30
1908	18,777,871	50
1909	24,549,758	51
1910	40,641,159	44
1911	46,562,825	43
1912	51,448,067	42
1913	58,398,432	46

CHAPTER VII.

LOS ANGELES AND ORANGE COUNTIES.

HISTORY OF DEVELOPMENT.

Oil and gas were early recognized in Los Angeles and Orange counties. In 1856 some effort was made to refine oil at Brea ranch. As early as 1865 Mr. A. Polhemus sunk a well 390 feet deep near Temple street, Los Angeles, and obtained some gas and water (Seventh Annual Report, State Mineralogist, p. 76). The earliest producing wells seems to have been in the Puente Field, Sections 34 and 35, T. 2 S., R. 10 W., where Lacey and Rowland drilled two wells prior to 1882 and by 1887 had six producers. Pico Canyon began producing in 1875, but is further mentioned with Ventura fields, which it closely adjoins.

Two grades of oil were obtained at Puente, 20° B. from the wells less than 300 feet deep, and 30° to 32° B. from those 800 feet to 1,000 feet deep. In 1887 the three deep wells were together producing about 100 barrels of the light oil per day, and the three shallow wells about forty or fifty barrels per month. The price of the light oil was $1.50 per barrel and the heavy oil sold for $5.00 per barrel. It is not stated whether these prices were at the well or in Los Angeles. The cost of drilling the deeper wells (800 to 1,000 feet) averaged $11.54 per foot. In 1893 there were twenty-five wells in the Puente Field, yielding 100,000 barrels (11 barrels per well day).

Near Olinda, Sections 5, 8 and 9, T. 3 S., R. 9 W., eight wells had been drilled near the brea outcrop along the fault line, but were idle in 1887.

The first producing well in Los Angeles City was drilled by Doheney & Connon in 1892 at Second Street Park (Bulletin No. 11, State Mining Bureau, p. 5). By the end of 1895 there were more than 300 wells, their yearly production being 729,695 (6 or 7 barrels per well day) and the average price of oil was as low as 60 cents per barrel, but the next year increased to $1.00. Drilling a 1,000 foot well and installing a pumping plant is reported as costing less than $2.50 per foot.

Development of the Salt Lake Field began in 1902. The history of development and production of these fields since 1903 is well shown by the accompanying diagrams (pages 309–313) made up from figures furnished by the Standard Oil Company.

Price and annual production is shown by the figures recorded in publications of the State Mining Bureau.

Whittier-Fullerton (see Plate XIV) includes all the fields east of Los Angeles (Fig. 55) and development may be summarized as follows:

From 1903 until the end of 1907 the number of producing wells varied between 200 and 300. It is particularly important to notice that the rate of production per well was almost constant at about 25 barrels. This is the only oil region in California showing such steady production.

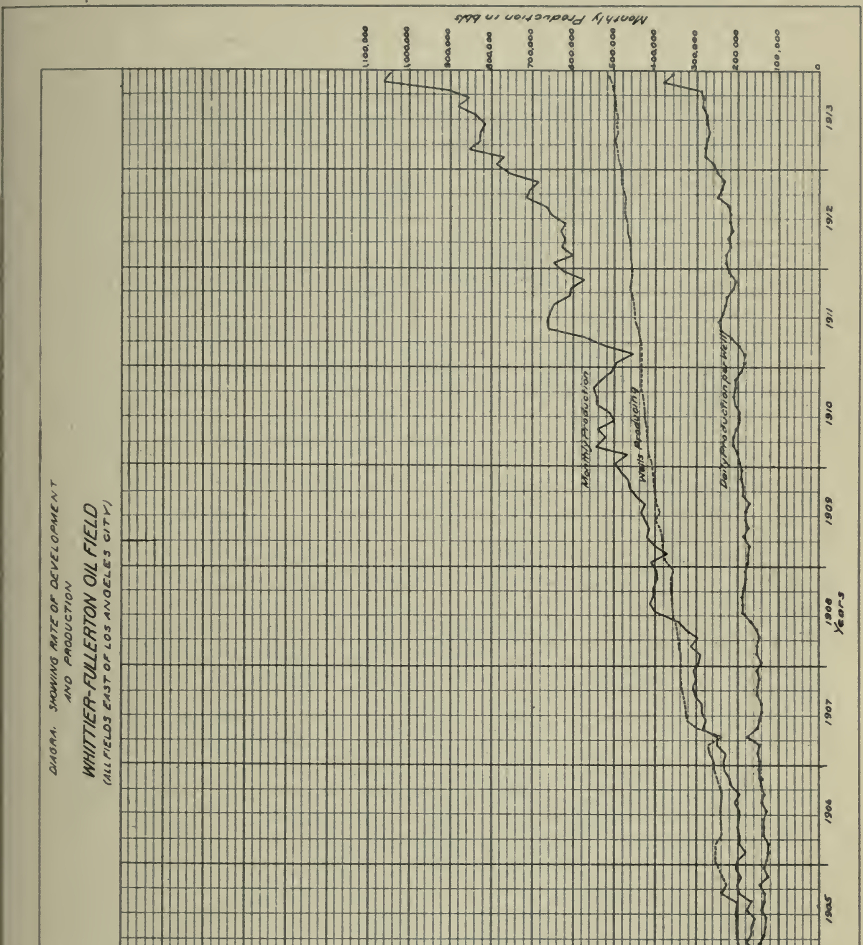


Fig. 55.

The total monthly production increased from 150,000 to 300,000 barrels. From the beginning of 1908 until the end of 1913 there has been a uniform rate of development of about 30 new wells per year (336 to

514). As much of this development has been in virgin territory the rate of production has increased from 25 barrels to 60 barrels per well. The monthly production has raised from 300,000 barrels to about 1,000,000 barrels.

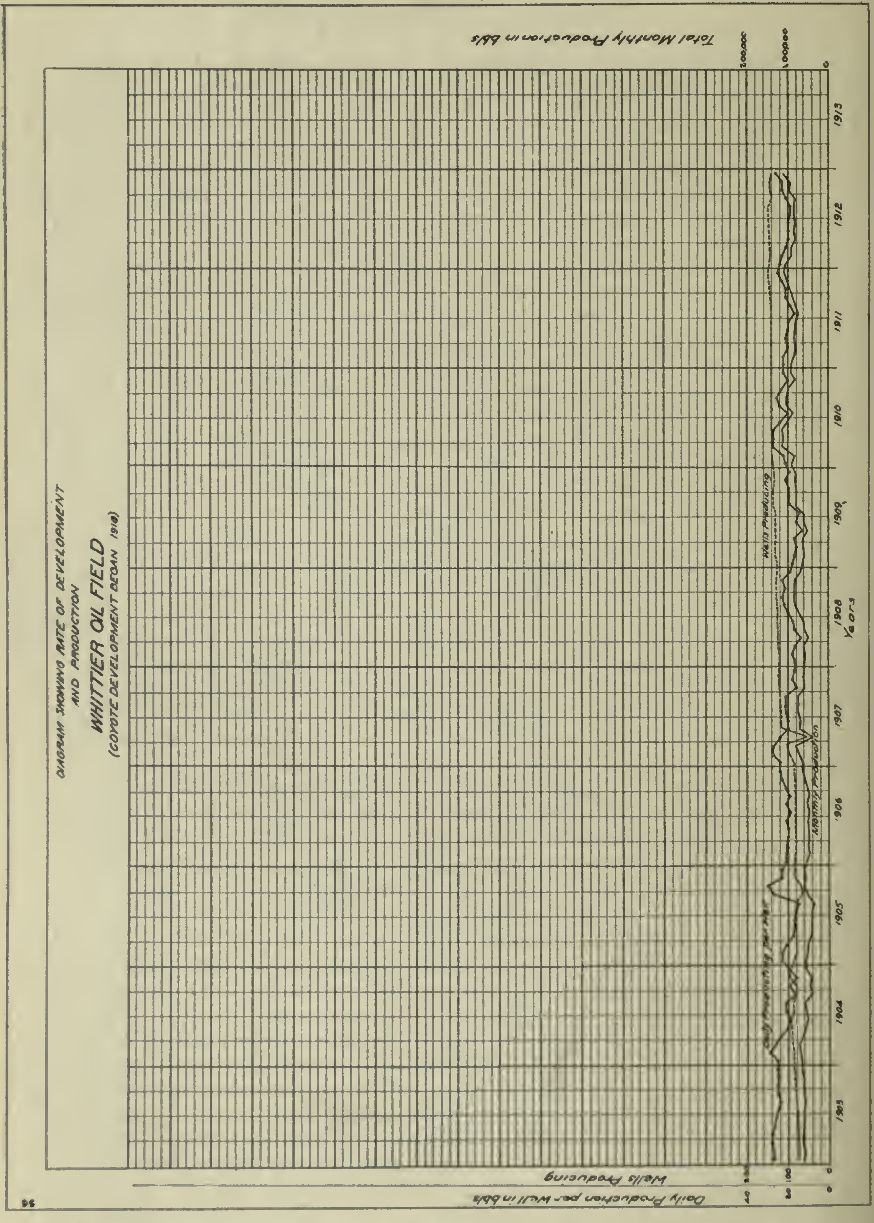


Fig. 56.

The Whittier-Coyote portion of the field (Fig. 56) shows very slow and gradual development from 1903 to 1912, about seven new wells per year (74 to 147) and an increase in monthly production from 60,000 to about 100,000 barrels. During 1910 some of the wells were in virgin ground which slightly increased the rate per well. It is most remarkable that during the seven years from 1903 to 1910 very little decrease in rates of production per well occurred, possibly falling from 26 to 18 barrels per day.

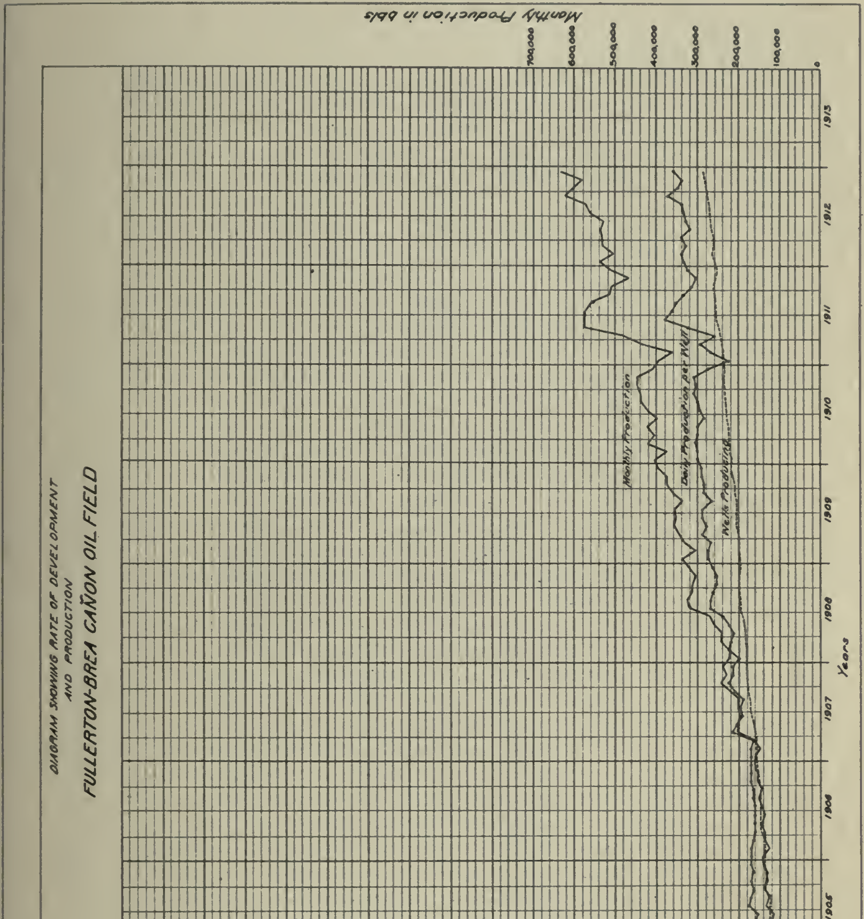


Fig. 57.

Fullerton-Brea Canyon. From 1903 until the end of 1906 there was little development, the number of wells increasing from 99 to 153 (14 per year), with an increase of monthly production from 110,000 to

150,000 barrels. The very slight decline in production per well is notable, 30 to 26 barrels. From 1907 until the end of 1912 there was an increase of development activity, the number of wells rising from 153 to 286 (22 per year), with the monthly production rising from 150,000 barrels to 636,000 barrels. The increase in rate per well was fairly uniform, from 24 to 70 barrels, indicating the opening of virgin ground.

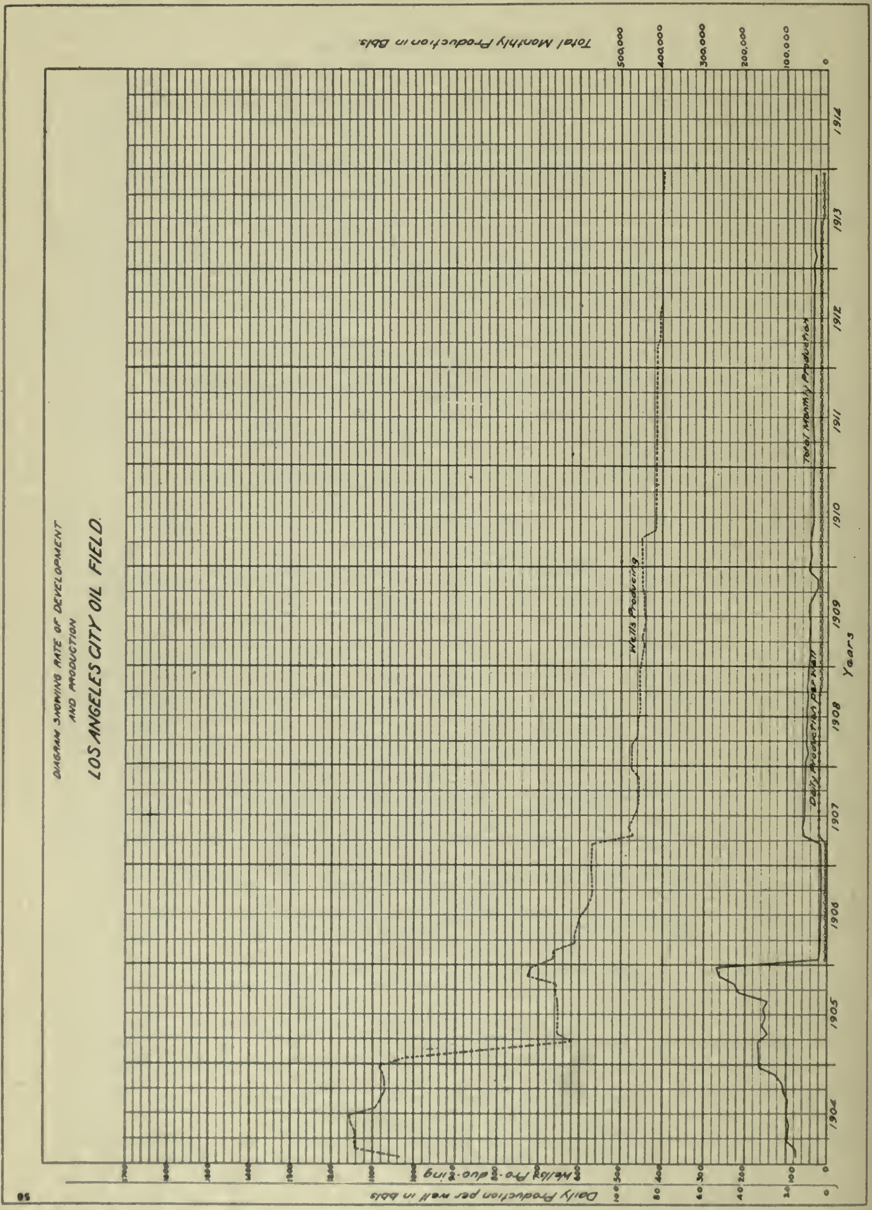


Fig. 58.

The Los Angeles City field figures (Fig. 58) show the rapid abandonment of wells. In 1904 there were about 1,150 producers and at the end of 1910 only 416. Such a decline in work was the natural sequence of the uneconomic development where wells were crowded together on city lots. No new work is allowed within the city limits and besides the field is probably thoroughly prospected and developed. Since 1910 the number of wells has remained nearly constant at a little over 400,

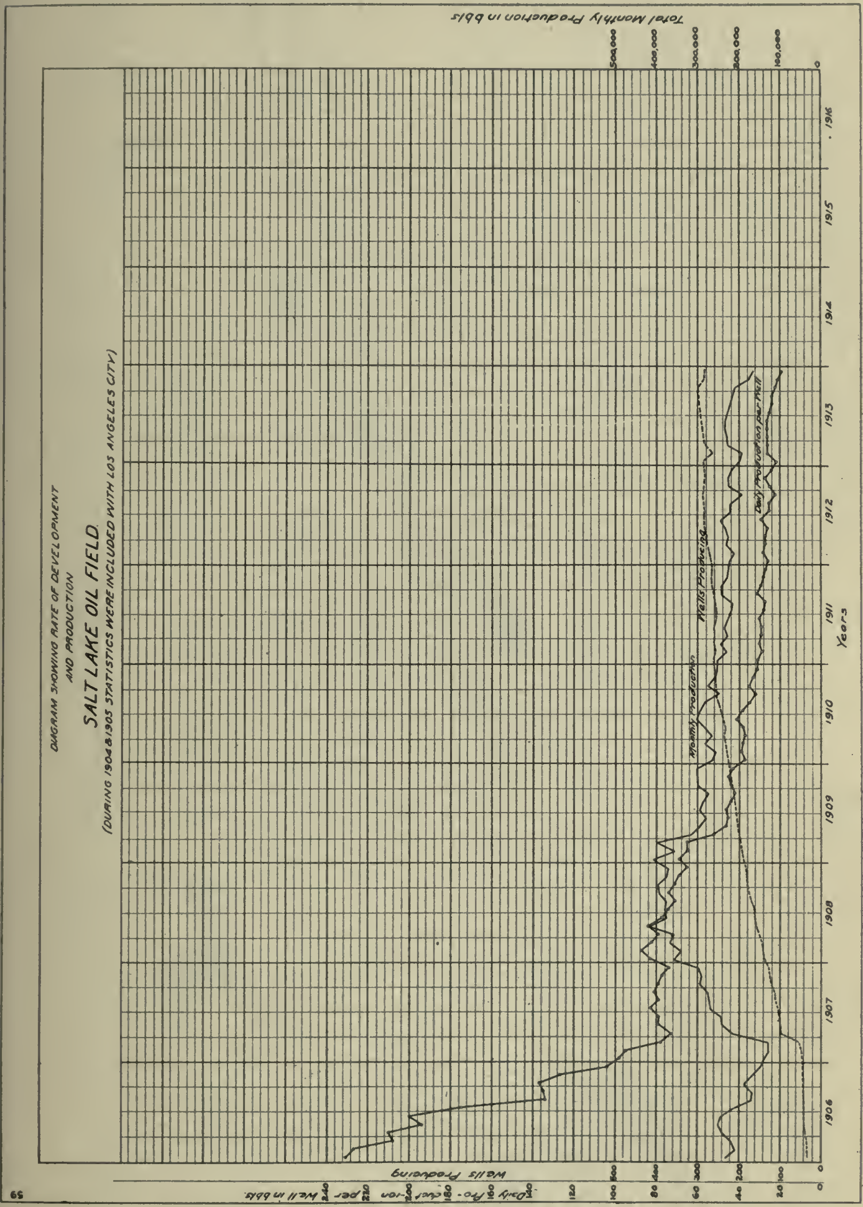


Fig. 59.

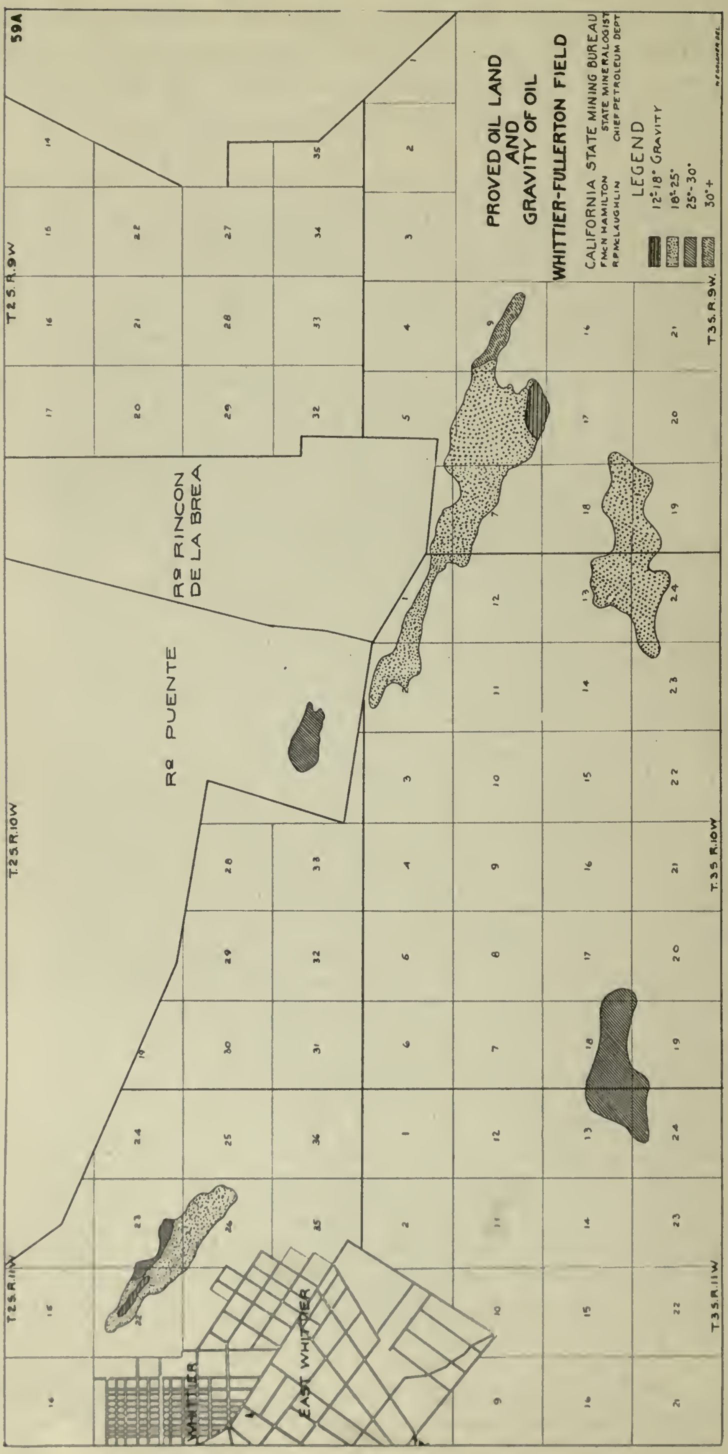


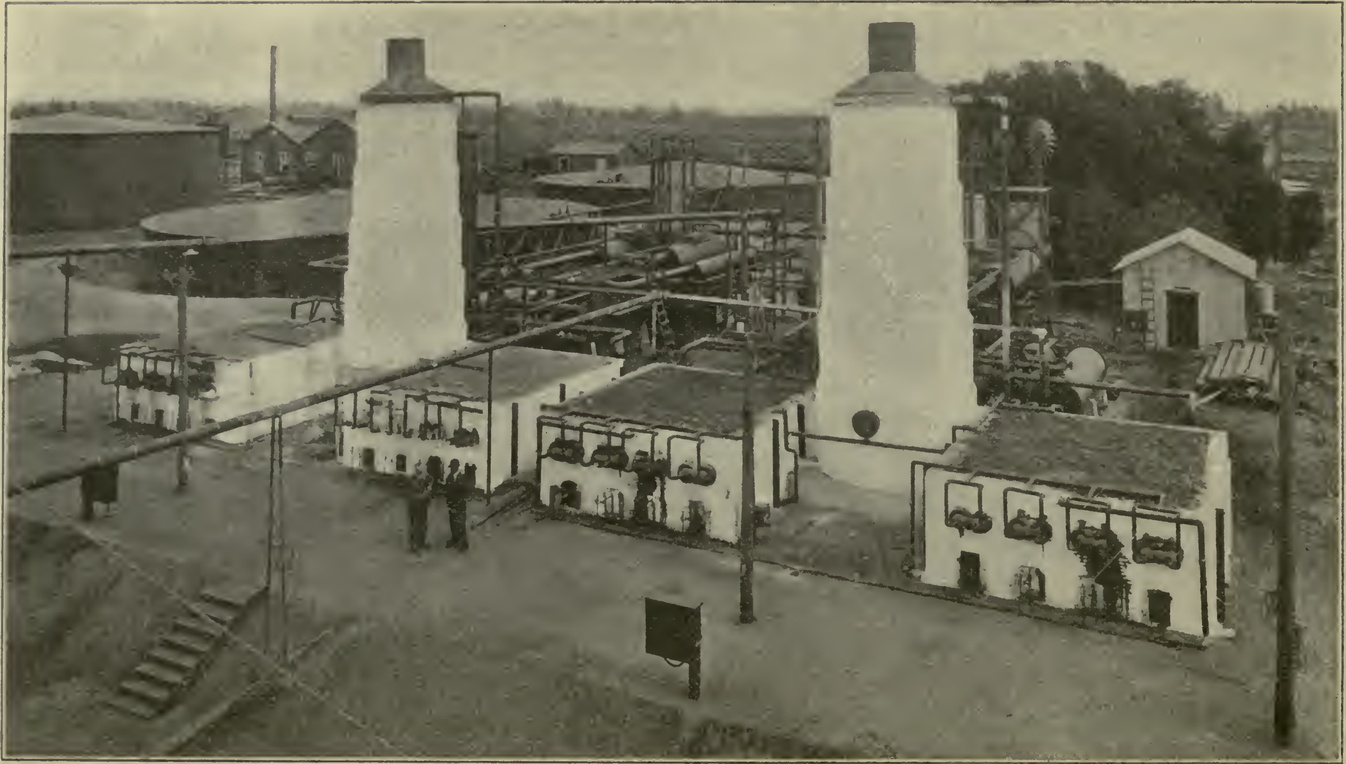
Fig. 59A. Proved Oil Land and Gravity of Oil. Whittier-Fullerton Field.

and since 1907 the monthly production has fallen from about 60,000 barrels to 30,000 barrels. The rate per well has been fairly uniform at from four to two barrels but is of little significance as many of the wells pump only occasionally. Altogether the figures illustrate conditions in a field that is nearly exhausted and slowly approaching abandonment.

The Salt Lake Field (see Plate XIII) began developing in 1902 and until 1906 the production and wells were carried on the city report. Early in 1907 the number of wells reached 100 and active development, until the end of 1909, increased the number to 226 (32 per year). Until the end of 1913 development slowed up to the rate of 19 wells per year, making a total of 283. Monthly production fluctuated from 250,000 barrels in 1906 to 130,000 in 1907, rising to a maximum of over 400,000 in 1908. Since then it has steadily declined to about 200,000 barrels. The change in rate of production per well day is entirely different from that in the fields east of Los Angeles and similar to that in the San Joaquin Valley fields; early in 1906 it was about 230 barrels and fell rapidly to 80 barrels early in 1907; since then the decline has been slower (during the past four years it has been at the rate of about 4½ barrels per year), until it stood at about 20 barrels at the end of 1913.

Summarizing on these figures it may be said that the older portions of the Whittier-Fullerton field are remarkable for their slow decline and should continue to pump for a great many years (possibly ten or twenty). They may even pay when reduced to such a low stage as is the city field where two or three barrels per well day is now the average. The newer portions of the field south of the main range of the Puente Hills seem to have already yielded nearly as much oil as the older portion. Prediction of extent and life of the newer fields is very uncertain at present, but it is probable that expenses will be greater and that the decline will be more rapid than in the older portion. It seems quite possible that the ultimate proved area in the new region may double that now known.

Predictions as to the Salt Lake Field are less hazardous. Unless costs are greatly reduced wells will probably be abandoned when falling as low as five or ten barrels per day and the present rate indicates that ten years, and possibly five, will see many wells in this class. Any considerable extension of the field seems improbable in view of the margin of abandoned wells. However, the flat lands throughout the region around Los Angeles effectually mask the underground conditions and it must be borne in mind that there are possibilities that future drilling may develop considerable areas, particularly along the series of low hills extending from Beverly to Los Cerritos, near Inglewood, Howard Summit and Dominguez Hill. Further mention of this subject is made in the geologic description.



Refinery of General Petroleum Company (Trumble type) at Los Angeles.

LIFE OF WELLS.

Life of wells in the fields east of Los Angeles is remarkably long, some of them now being possibly thirty years old. However, their production is frequently very small and some are only pumped a few days each month. It is not possible or necessary to summarize the rate of decline as was done with the diagrams of properties in the San Joaquin fields. However, attention is particularly directed to the diagrams (Figs. 60–66) and the yield per acre which is not surprisingly high, but it must be remembered that the earliest records were frequently not available. Results here do not seem applicable for appraisal of other fields.

Water is a greater source of trouble in this region than public reports would indicate. Operators have given too little attention to the matter, but enough information is at hand to warrant the statement that the expense of a systematic investigation will be a profitable investment.

ANNUAL PRODUCTION AND PRICE OF OIL.

Los Angeles County.

Year	Barrels	Price per barrel
1894	475,650	$1 30
1895	979,695	75
1896	953,734	85
1897	1,327,011	1 00
1898	1,462,871	1 00
1899	1,409,356	1 00
1900	1,722,887	1 00
1901	2,304,432	46
1902	2,198,496	49
1903	1,960,604	66
1904	2,190,000	59
1905	2,854,564	37
1906	2,814,000	32
1907	4,318,739	61
1908	6,244,347	66
1909	5,409,392	65
1910	5,127,266	62
1911	4,924,288	67
1912	4,484,590	62
1913	4,143,690	65

Orange County.

1897	12,000	$1 00
1898	60,000	1 00
1899	108,077	1 00
1900	254,397	1 00
1901	302,652	60
1902	1,103,793	75
1903	1,355,104	75
1904	1,470,000	78
1905	1,510,900	47
1906	2,388,000	50
1907	2,426,750	60
1908	3,376,689	75
1909	4,270,967	63
1910	5,044,001	63
1911	6,345,275	65
1912	6,704,421	67
1913	9,485,362	72

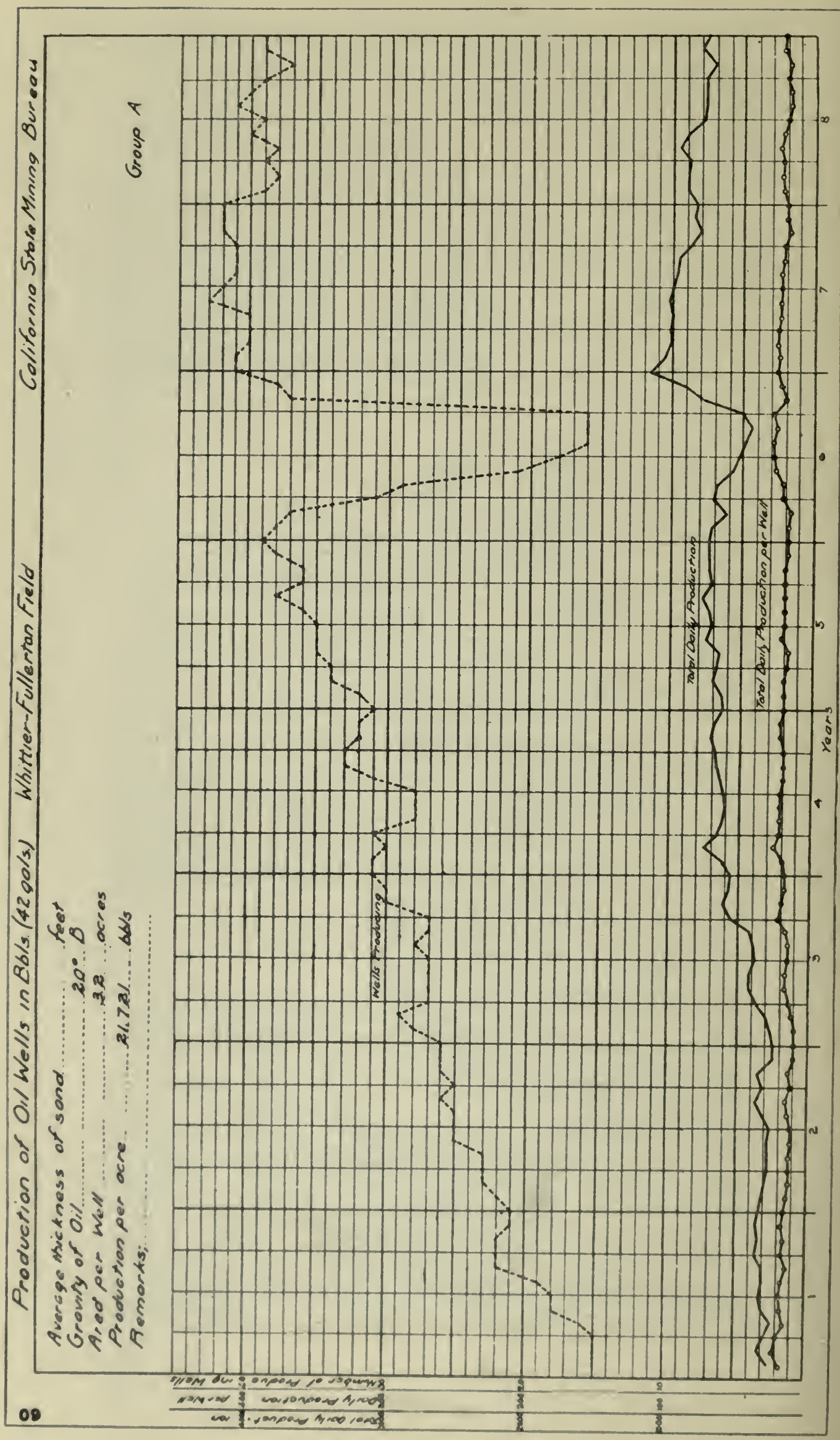


Fig. 60. Production record of 43 wells.

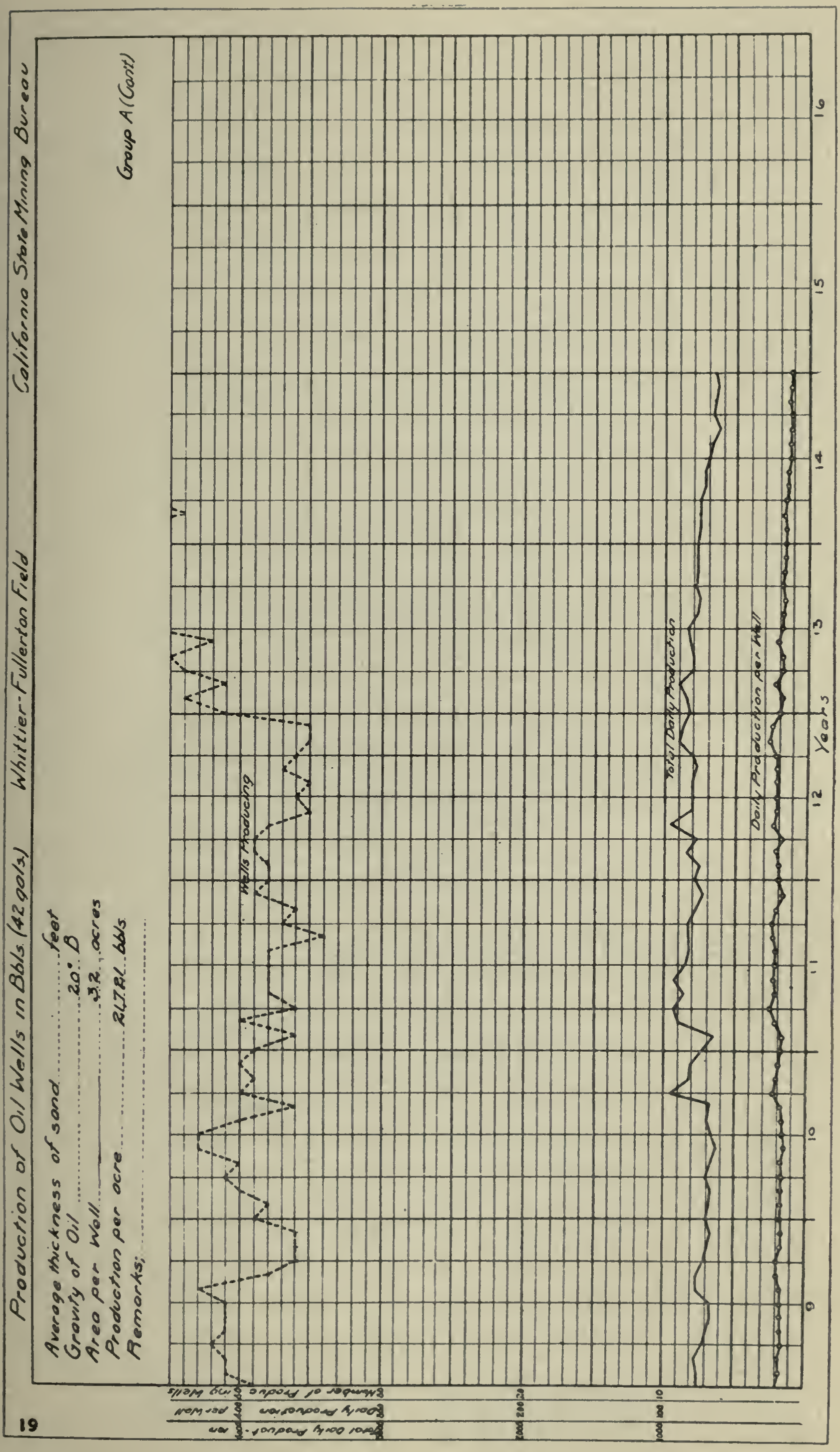


Fig. 61. Production record of 45 wells.

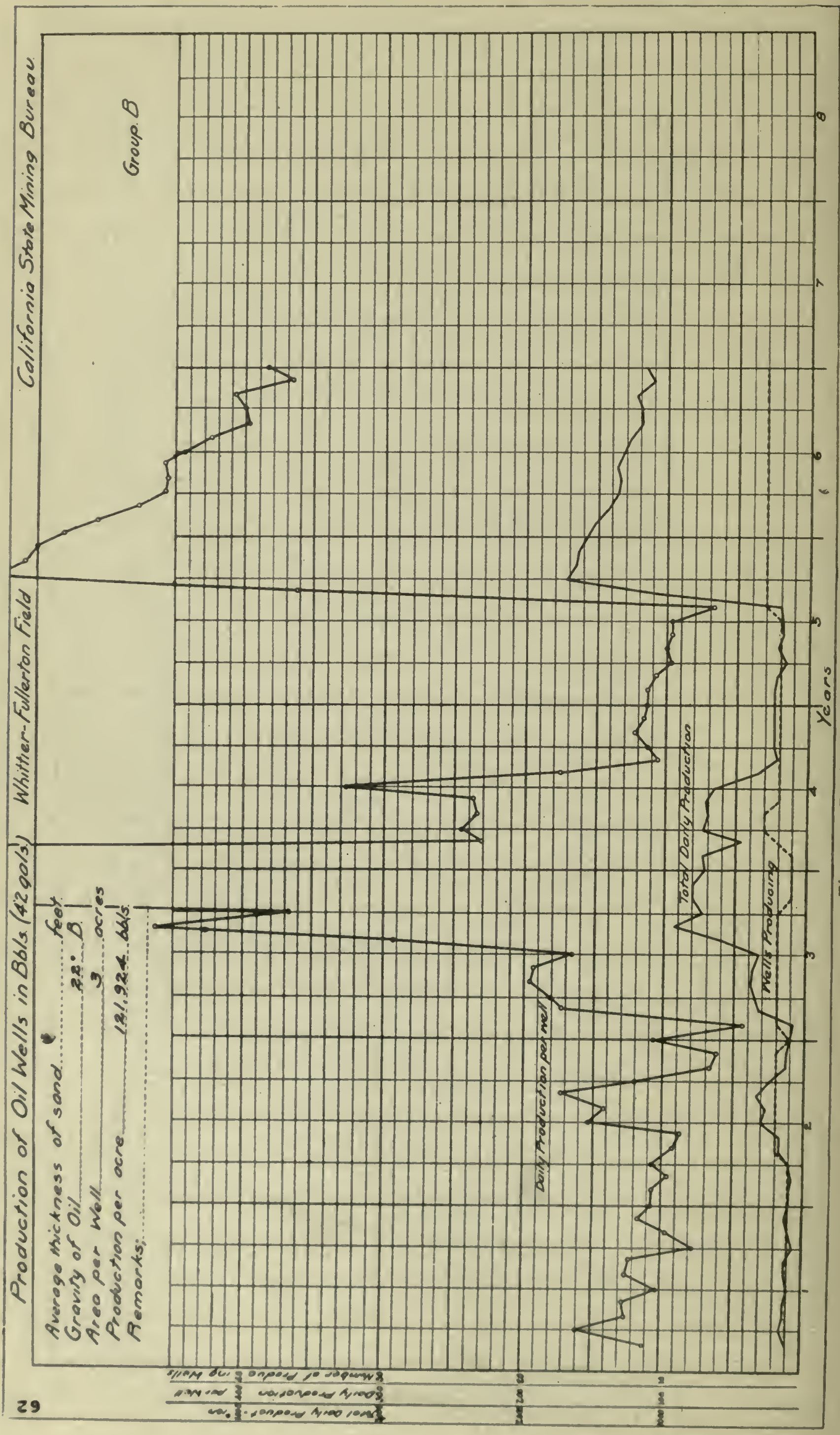


Fig. 62. Production record of 3 wells.

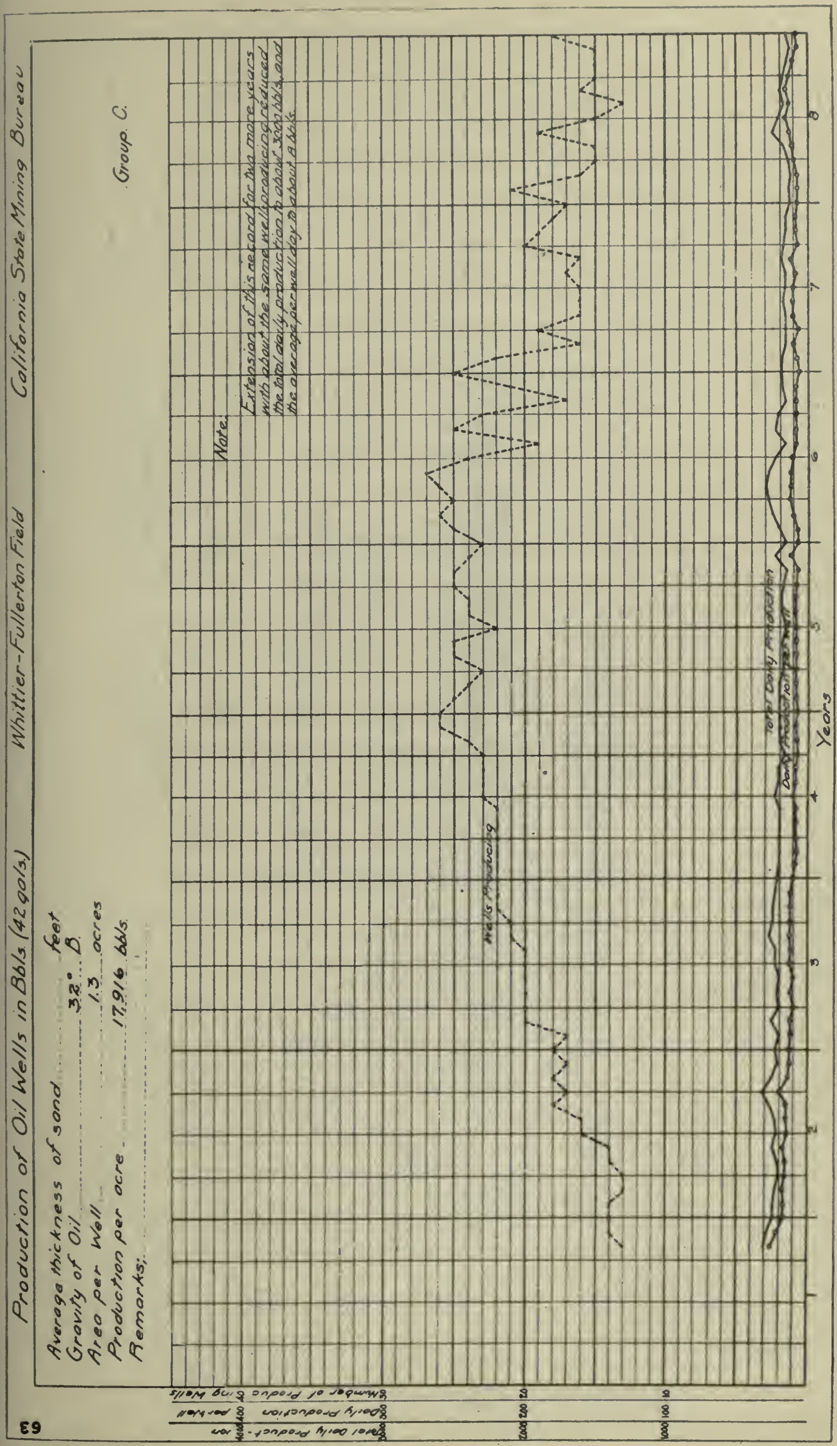
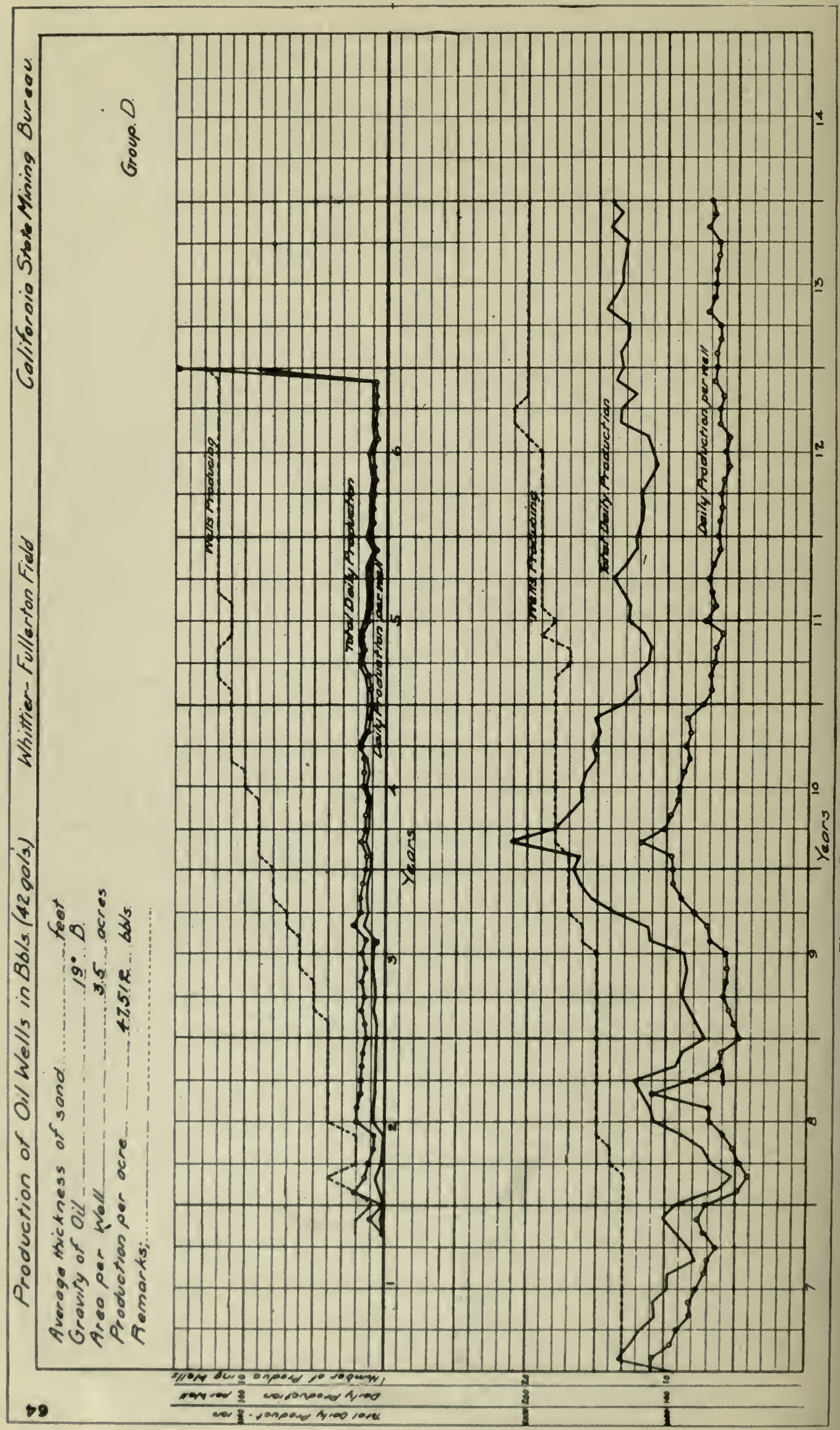


Fig. 63. Production record of 27 wells.



Production of Oil Wells in Bbls. (42 gals.) Whittier-Fullerton Field California State Mining Bureau.

Average thickness of sand .... feet.
Gravity of Oil .... 19° B.
Area per Well .... 3.5 acres
Production per acre .... 47,518 bbls.
Remarks; ....

Group D.

Fig. 64. Production record of 33 wells.

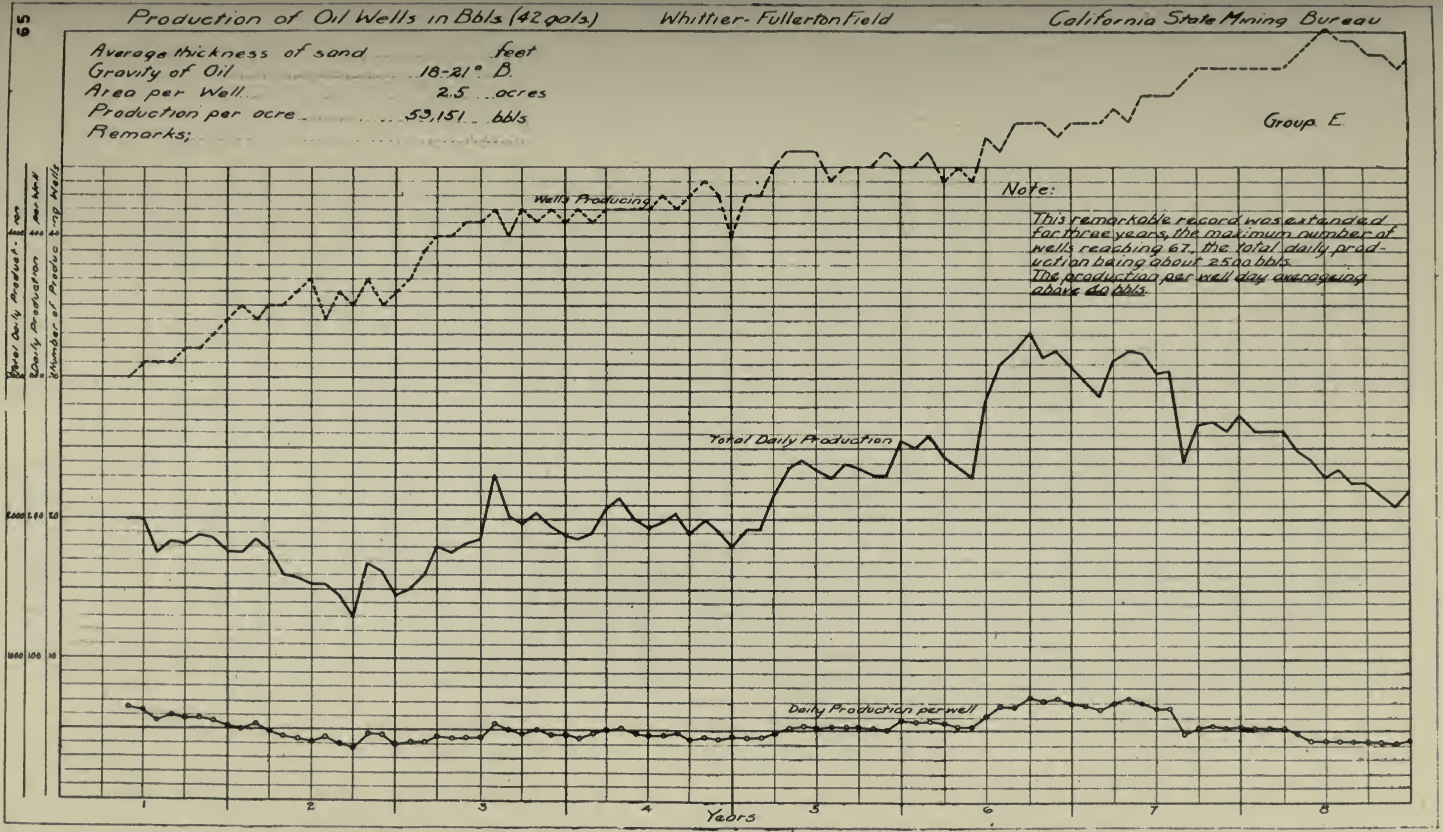


Fig. 65. Production record of 55 wells.

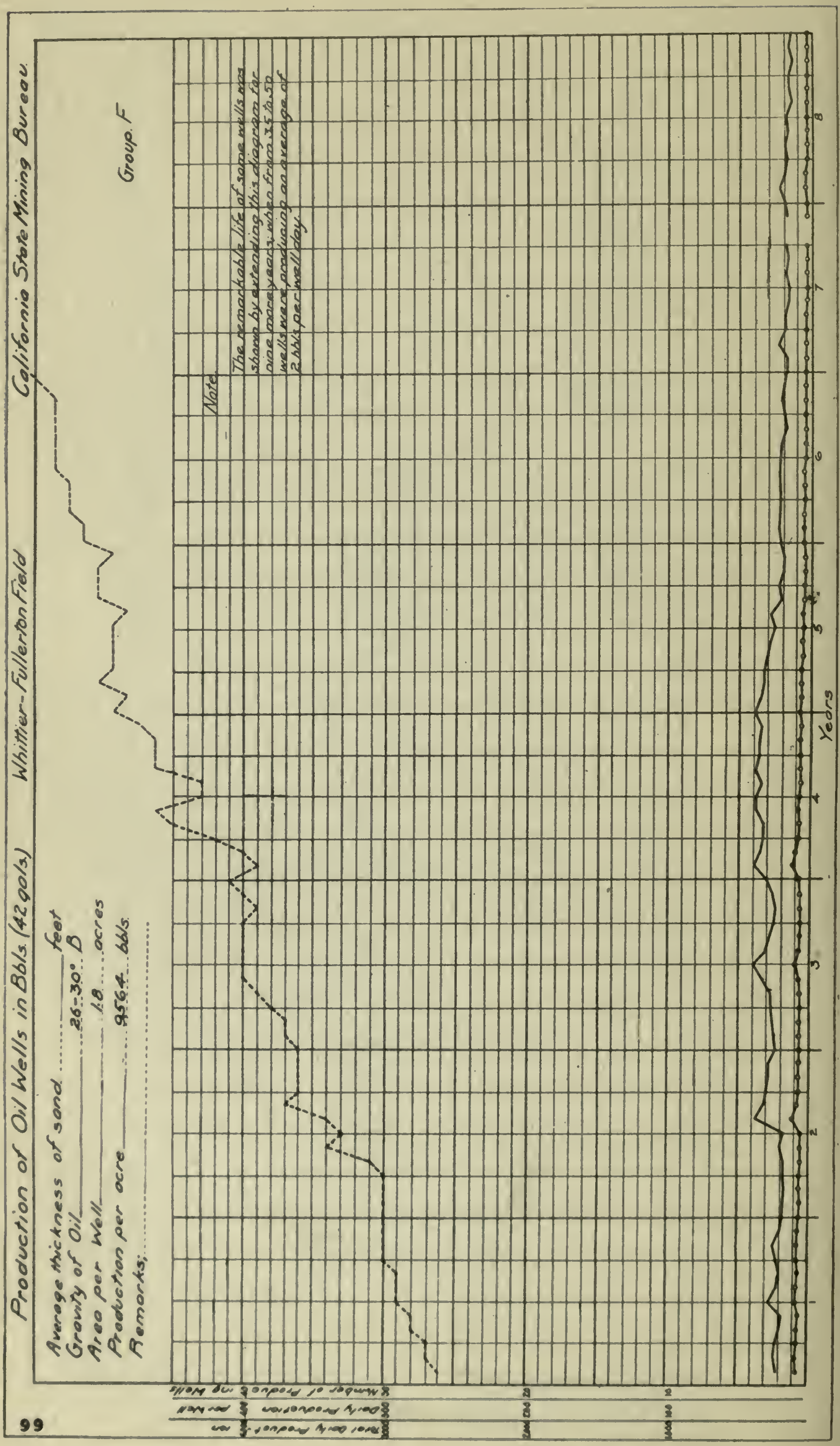


Fig. 66. Production record of about 50 wells.

FINANCIAL RESULTS.

Financial results in the Los Angeles and Orange County fields during the year 1913, as shown by twenty-seven companies, producing 5,319,816 barrels of oil from 482 wells, are summarized as follows:

Capital. This figure can not be definitely determined, particularly the second item (property value) and any error here is apt to be on the side of an overestimate.

Cash paid for stock	$4,247,826 00
Property paid for stock	7,329,343 00
	$11,577,169 00

Dividends are difficult to determine as many concerns are close corporations, making no public reports, hence our figures may be slightly below the actual amounts. Records earlier than 1909 were not available:

1909, 12 companies	$1,203,556 00
1910, 13 companies	1,427,908 00
1911, 12 companies	1,288,034 00
1912, 12 companies	878,478 00
1913, 14 companies	3,015,159 00
	$7,813,135 00

Of the fourteen dividend paying companies, ten have paid continuously since 1909, only one being simply from royalty. The oil produced by the dividend companies was 5,374,000 barrels, or 39 per cent of the field total. These fields (see table, page 10) stand third in the list of amount of oil produced, and yet pay more than three times the amount of dividends of any other field. The price received for the oil is much higher than in any other field, doubtless due to the fact that markets almost adjoin the producing properties, thereby eliminating most of the transporting cost and marketers' profit.

MONTHLY PRODUCTION AND WELL RECORDS.

LOS ANGELES CITY AND SALT LAKE.

(Figures by Standard Oil Company.)

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1904.				
January	1,033	----------	75,547	2
February	1,142	----------	76,227	2
March	1,144	----------	99,153	3
April	1,142	----------	96,870	3
May	1,152	----------	93,153	3
June	1,155	----------	97,590	3
July	1,093	----------	98,563	3
August	1,081	----------	95,543	3
September	1,074	----------	106,220	3
October	1,074	----------	110,564	3
November	1,075	----------	125,220	4
December	1,084	----------	166,654	5
Total	----------	----------	1,241,304	
1905.				
January	1,024	----------	165,736	5
February	842	----------	166,680	7
March	619	----------	168,097	9
April	654	----------	145,175	7
May	654	----------	158,100	8
June	653	----------	150,000	8
July	653	----------	155,000	8
August	653	----------	145,700	7
September	659	----------	215,400	11
October	655	----------	224,750	12
November	728	----------	262,740	12
December	719	----------	269,390	12
Total	----------	----------	2,226,768	

Los Angeles City Field.

(Standard Oil Company.)

1906.				
January	665	----------	20,925	1
February	662	----------	18,620	1
March	610	----------	18,600	1
April	611	----------	18,300	1
May	606	----------	18,600	1
June	601	----------	18,000	1
July	585	----------	16,275	1
August	574	----------	15,500	1
September	570	----------	14,880	1
October	571	----------	16,275	1
November	570	----------	16,500	1
December	572	----------	17,825	1
Total	----------	----------	210,300	
1907.				
January	572	----------	17,825	1
February	570	----------	16,240	1
March	570	----------	17,670	1
April	473	----------	58,280	4
May	481	----------	61,005	4
June	471	----------	57,410	4
July	462	----------	55,510	4
August	457	----------	56,290	4
September	457	----------	55,710	4
October	457	----------	55,715	4
November	457	1	54,310	4
December	476	----------	54,700	4
Totals	----------	1	560,665	

Los Angeles City Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1908.				
January	476		54,002	4
February	476		49,300	4
March	475		52,948	4
April	460		50,130	4
May	460		51,755	4
June	460		49,910	4
July	455		51,242	4
August	455		50,816	4
September	456		47,970	4
October	456		50,115	3
November	456		47,940	3
December	456		47,031	3
Total			603,159	
1909.				
January	450		45,898	3
February	450		41,600	3
March	444		44,980	3
April	450		45,040	3
May	444		44,298	3
June	440		43,740	3
July	446		46,405	3
August	446		44,895	3
September	446		43,500	3
October	450		42,423	3
November	450		42,480	3
December	450	1	44,506	3
Totals		1	529,765	
1910.				
January	451		44,404	3
February	451		40,315	3
March	451		42,923	3
April	451		41,240	3
May	418		39,639	3
June	418		36,750	3
July	418		37,584	3
August	416		36,728	3
September	416		36,550	3
October	416		37,358	3
November	416		36,106	3
December	416		36,917	3
Total			466,514	
1911.				
January	416		36,410	3
February	415		32,604	3
March	415		36,076	3
April	415		35,100	3
May	415		36,936	3
June	415		35,920	3
July	415		37,213	3
August	415		37,142	3
September	415		36,380	3
October	415		36,276	3
November	415		34,620	3
December	413		34,751	3
Total			429,428	

Los Angeles City Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1912.				
January	413	------------	35,301	3
February	413	------------	33,595	3
March	413	------------	36,930	3
April	406	------------	34,170	3
May	406	------------	35,340	3
June	406	------------	34,310	3
July	406	------------	34,750	3
August	401	------------	33,835	3
September	401	------------	33,965	3
October	401	------------	33,965	3
November	401	------------	32,275	3
December	400	------------	33,310	3
Totals	------------	------------	411,746	
1913.				
January	400	------------	32,520	3
February	400	------------	29,468	3
March	400	------------	32,620	3
April	400	------------	31,530	3
May	400	------------	32,581	3
June	400	------------	31,240	3
July	400	------------	29,899	2
August	400	------------	29,929	2
September	400	------------	29,330	2
October	399	------------	29,988	2
November	399	------------	28,890	2
December	399	------------	29,676	2
Total	------------	------------	367,671	

SALT LAKE FIELD.

1904 and 1905. See Salt Lake and Los Angeles City.

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1906				
January	32	------------	230,950	231
February	33	1	210,000	227
March	34	1	220,100	208
April	38	8	240,000	210
May	42	1	252,400	194
June	41	1	243,000	200
July	40	1	215,450	175
August	41	1	170,500	134
September	42	2	169,500	135
October	45	1	190,650	137
November	45	------------	177,000	127
December	46	1	148,800	104
Totals	------------	18	2,435,350	
1907				
January	47	1	142,600	98
February	49	5	130,200	95
March	54	2	130,200	78
April	98	2	216,500	73
May	99	3	241,950	79
June	102	4	243,400	79
July	105	7	270,700	83
August	112	4	273,200	79
September	113	5	276,050	81
October	121	4	297,000	79
November	125	5	290,500	77
December	130	10	299,500	74
Totals	------------	52	2,811,800	
1908				
January	140	4	359,400	83
February	141	4	342,780	87
March	146	3	339,790	82
April	152	8	360,700	79
May	160	6	419,540	84
June	163	2	377,900	77
July	165	7	380,170	74
August	172	6	378,870	71
September	177	4	396,000	74
October	181	4	399,850	71
November	182	4	379,200	69
December	185	5	371,600	65
Totals	------------	57	4,535,800	
1909				
January	191	1	410,400	69
February	194	6	356,060	65
March	199	4	400,900	65
April	203	4	317,829	52
May	206	2	295,151	43
June	208	3	279,790	45
July	209	5	295,623	46
August	213	1	288,995	44
September	214	9	272,047	42
October	221	4	300,891	44
November	224	4	302,292	45
December	226	5	301,155	43
Totals	------------	48	3,821,133	

Salt Lake Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1910				
January	231	3	264,833	37
February	233	6	256,334	39
March	237	4	281,303	38
April	240	2	268,357	37
May	238	4	281,457	38
June	242	5	301,890	41
July	248	3	293,265	38
August	255	1	280,949	35
September	256	2	247,339	32
October	257	----------	277,102	35
November	257	5	257,364	33
December	261	2	252,911	31
Totals	----------	37	3,263,104	
1911				
January	263	----------	253,376	31
February	257	4	230,517	29
March	261	1	244,890	30
April	260	1	227,366	29
May	261	1	235,387	29
June	256	1	228,285	30
July	255	1	219,212	28
August	258	2	216,349	27
September	262	4	243,716	31
October	267	1	243,208	29
November	269	2	227,039	28
December	267	1	224,888	27
Totals	----------	19	2,794,233	
1912				
January	269	2	221,093	26
February	272	2	210,157	28
March	277	4	230,197	27
April	280	1	225,045	27
May	285	----------	232,176	26
June	285	1	244,414	29
July	283	2	218,583	25
August	285	1	220,372	25
September	289	----------	191,893	22
October	286	3	225,601	25
November	283	2	225,506	27
December	286	2	217,739	24
Totals	----------	20	2,662,776	
1913				
January	287	1	199,886	22
February	264	1	192,902	26
March	285	3	229,439	26
April	288	2	229,908	26
May	291	----------	234,821	26
June	292	2	231,395	26
July	296	3	226,054	25
August	298	1	221,941	24
September	299	1	213,450	24
October	299	----------	209,975	22
November	284	3	176,489	21
December	283	----------	164,915	19
Totals	----------	17	2,531,175	

WHITTIER-FULLERTON.

(All fields east of Los Angeles.)

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1903				
January	223	------------	188,418	27
February	221	------------	176,400	29
March	215	------------	190,867	29
April	216	------------	183,300	28
May	233	4	184,626	26
June	242	4	184,002	25
July	247	7	193,115	25
August	259	6	200,694	25
September	261	6	201,300	26
October	272	4	200,818	24
November	276	7	200,430	24
December	282	3	201,643	23
Totals	------------	41	2,305,613	
1904				
January	285	3	203,448	23
February	288	6	201,820	25
March	294	2	207,228	23
April	296	3	189,290	21
May	298	4	187,362	20
June	302	3	183,010	20
July	292	9	189,380	21
August	283	3	193,990	22
September	275	------------	160,150	19
October	221	9	162,023	24
November	260	------------	169,787	22
December	212	2	177,062	27
Totals	------------	44	2,224,550	
1905				
January	204	------------	172,733	27
February	192	------------	151,108	28
March	198	------------	176,810	29
April	202	------------	164,750	27
May	202	------------	164,300	26
June	203	------------	156,000	26
July	204	------------	176,187	28
August	200	------------	164,300	27
September	239	------------	195,750	27
October	227	------------	201,500	29
November	236	------------	190,825	27
December	245	------------	204,445	------------
Total	------------	------------	2,118,708	
1906				
January	255	2	202,368	26
February	253	1	179,480	25
March	254	------------	194,866	25
April	239	------------	193,350	27
May	240	2	200,570	27
June	242	------------	195,490	27
July	242	------------	195,870	26
August	240	2	207,948	28
September	238	3	195,450	27
October	245	3	214,675	28
November	252	------------	220,800	29
December	257	1	232,500	29
Totals	------------	14	2,433,367	

Whittier-Fullerton—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1907				
January	258	3	232,500	29
February	269	3	226,856	30
March	272	3	248,000	29
April	236	------------	248,800	35
May	300	1	281,000	30
June	321	2	274,400	29
July	324	3	285,700	28
August	325	6	284,550	28
September	330	4	301,000	30
October	333	3	308,600	30
November	335	3	298,100	29
December	337	1	304,700	30
Totals		32	3,294,206	
1908				
January	336	4	292,507	28
February	334	3	287,367	30
March	340	3	312,208	30
April	341	3	295,120	29
May	344	4	326,840	30
June	349	7	342,208	33
July	354	4	403,150	37
August	357	3	414,944	37
September	360	2	403,800	37
October	361	1	403,600	36
November	361	2	394,450	36
December	355	2	397,120	33
Totals		38	4,273,314	
1909				
January	376	------------	410,750	35
February	382	4	370,856	35
March	383	2	402,496	34
April	383	7	420,554	37
May	387	2	413,429	35
June	400	1	426,598	36
July	389	3	434,070	36
August	396	5	423,745	34
September	400	4	445,695	37
October	402	2	461,003	37
November	404	6	463,953	38
December	409	1	483,903	38
Totals		37	5,157,652	
1910				
January	410	2	499,311	39
February	417	1	465,255	40
March	418	2	545,057	42
April	419	2	524,422	42
May	421	5	542,436	41
June	425	3	502,718	39
July	425	5	513,476	39
August	428	2	546,987	41
September	430	3	547,324	42
October	434	2	552,249	41
November	433	3	533,828	41
December	432	1	508,158	38
Totals		31	6,281,221	

Whittier-Fullerton—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1911				
January	433	------------	493,190	37
February	433	3	450,490	37
March	433	4	523,177	39
April	438	2	572,004	43
May	441	4	660,861	48
June	450	3	662,795	49
July	450	1	654,431	47
August	452	3	647,126	46
September	455	7	609,888	45
October	463	1	606,764	42
November	450	2	572,993	41
December	457	4	627,416	44
Totals	------------	34	7,081,165	
1912				
January	459	1	651,412	46
February	461	4	597,992	46
March	460	3	628,586	44
April	463	5	619,930	45
May	469	1	629,061	43
June	468	3	617,925	44
July	474	4	652,084	44
August	475	5	666,072	45
September	471	4	713,777	50
October	479	4	706,428	48
November	483	2	682,645	47
December	428	3	753,867	50
Totals	------------	39	7,919,779	

WHITTIER FIELD.

(Figures by Standard Oil Company.)

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1903.				
January	74	------------	62,000	27
February	76	------------	58,800	27
March	76	------------	65,410	28
April	76	------------	63,300	28
May	75	2	63,920	27
June	78	1	60,240	26
July	79	2	61,703	25
August	81	1	59,706	24
September	82	3	61,080	25
October	84	2	64,604	25
November	86	1	64,200	25
December	87	1	67,757	25
Totals	------------	13	752,720	
1904.				
January	88	------------	69,367	25
February	88	3	71,783	29
March	91	2	74,267	26
April	93	2	64,160	23
May	95	------------	58,182	20
June	95	------------	53,410	19
July	88	5	57,850	21
August	93	------------	60,450	21
September	83	------------	42,600	17
October	83	6	49,370	19
November	98	------------	45,600	16
December	92	2	57,410	20
Totals	------------	20	704,449	
1905.				
January	84	------------	59,340	23
February	79	------------	51,240	23
March	79	------------	51,030	21
April	80	------------	42,900	18
May	80	------------	43,400	17
June	81	------------	42,000	17
July	81	------------	40,900	16
August	80	------------	37,200	15
September	66	------------	53,950	27
October	68	------------	62,310	30
November	84	------------	57,700	23
December	86	------------	60,605	23
Total	------------	------------	602,575	
1906.				
January	86	1	55,800	21
February	82	------------	48,160	21
March	82	------------	52,700	21
April	82	------------	50,250	20
May	83	------------	52,545	20
June	83	------------	52,390	21
July	83	------------	48,000	19
August	83	------------	54,250	21
September	83	1	48,000	19
October	84	2	54,250	21
November	87	------------	60,300	23
December	88	------------	65,100	24
Totals	------------	4	641,745	

Whittier Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1907.				
January	88	------------	65,100	24
February	99	3	74,256	27
March	102	1	82,150	27
April	53	------------	38,700	24
May	116	1	72,900	20
June	117	1	70,000	20
July	118	1	77,800	21
August	118	1	77,200	21
September	119	2	75,000	21
October	120	2	60,400	16
November	121	1	64,000	18
December	121	------------	62,500	17
Totals	------------	13	820,006	
1908.				
January	120	2	63,400	17
February	119	1	60,430	18
March	123	------------	64,590	17
April	123	1	51,950	14
May	123	1	63,640	17
June	125	1	66,450	18
July	124	3	78,850	20
August	126	1	86,490	22
September	127	1	88,200	23
October	128	1	88,800	22
November	128	------------	87,750	23
December	125	------------	72,660	19
Totals	------------	12	873,210	
1909.				
January	125	------------	68,720	18
February	130	2	62,960	17
March	129	1	65,900	16
April	129	2	69,900	17
May	128	1	52,725	13
June	129	------------	61,207	16
July	128	1	61,360	15
August	134	------------	81,215	19
September	135	2	79,115	19
October	136	------------	80,399	19
November	133	1	83,214	21
December	134	1	81,070	19
Totals	------------	11	847,785	

WHITTIER-COYOTE FIELD.

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1910.				
January	137		90,550	21
February	138		85,910	22
March	138		115,440	27
April	137	1	112,858	27
May	139	1	115,443	27
June	140	2	100,976	24
July	140	1	87,026	20
August	140		104,810	24
September	140		104,480	25
October	141		100,710	23
November	140	1	83,219	20
December	140		96,838	22
Totals		6	1,198,260	
1911.				
January	140		93,921	22
February	140		85,581	22
March	138		83,868	20
April	137	1	85,006	21
May	137		83,823	20
June	140		82,250	20
July	140		75,117	17
August	140	1	81,561	19
September	142	3	89,535	21
October	145	1	94,097	21
November	147		102,509	23
December	147		112,169	25
Totals		6	1,069,437	
1912.				
January	144	1	108,675	24
February	141	3	92,330	23
March	143	1	93,337	21
April	144		84,317	20
May	144		88,275	20
June	143	2	85,311	20
July	146	3	87,277	19
August	147	1	87,359	19
September	139		85,773	21
October	143	1	100,608	23
November	144		97,934	23
December	140	1	114,573	26
Totals		13	1,125,769	
Total completed		97		
Idle or abandoned		31		

PUENTE FIELD.

(Figures by Standard Oil Company.)

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1903.				
January	50		12,400	
February	50		11,200	
March	51		12,400	
April	51		12,000	
May	68		11,780	
June	68		11,400	
July	68	1	11,935	
August	69		11,780	
September	69		8,280	
October	69		7,502	
November	69	1	7,320	
December	69		7,161	
Totals		2	125,158	
1904.				
January	69		7,161	
February	69		6,177	
March	69		4,991	
April	69		4,830	
May	69		4,805	
June	69		4,800	
July	65		4,650	
August	65		4,650	
September	65		4,500	
October	32		3,100	
November	32		3,000	
December			*	
Totals			52,664	
1905.				
January			*	
February			*	
March			*	
April			*	
May			*	
June			*	
July			*	
August			*	
September	35		3,000	
October	31		2,790	
November	20		2,250	
December	24		2,790	
Totals			10,830	
1906.				
January	33		3,968	
February	36		3,920	
March	36		4,216	
April	12		3,750	
May	12		3,875	
June	12		3,750	
July	12		3,875	
August	10		3,658	
September	8		3,450	
October	12		3,875	
November	16		4,500	
December	16		4,650	
Totals			47,487	

*Wells shut in.

Puente Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1907.				
January	16		4,650	
February	15		4,200	
March	15		4,650	
April	23		4,000	
May	23		4,000	
June	36		4,500	
July	36		4,500	
August	36		4,500	
September	36		4,500	
October	36		3,700	
November	36		3,600	
December	36		2,700	
Total			49,500	
1908.				
January	36		2,500	
February	36		2,000	
March	36		2,130	
April	36		1,920	
May	36		2,000	
June	36		1,860	
July	36		1,900	
August	36		1,900	
September	36		1,800	
October	36		1,800	
November	36		1,800	
December	36		1,860	
Total			23,470	
1909.				
January	54		3,900	
February	54		3,600	
March	54		3,100	
April	54		3,000	
May	54		2,900	
June	54		3,000	
July	54		3,250	
August	54		3,200	
September	54		3,000	
October	54		3,200	
November	54		3,100	
December	54		3,250	
Total			38,500	
1910.				
January	54		3,200	
February	54		2,900	
March	54		3,100	
April	54		3,000	
May	54		3,800	
June	54		3,100	
July	53	1	3,300	
August	54		3,560	
September	54	1	3,300	
October	55		3,400	
November	55		3,200	
December	55		3,100	
Totals		2	38,960	

Puente Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1911.				
January	55		3,100	
February	55		2,800	
March	55		3,225	
April	56		3,100	
May	56		2,700	
June	56		2,600	
July	56		2,660	
August	56		2,600	
September	56		2,550	
October	56		2,570	
November	56		2,500	
December	56		2,550	
Total			32,955	
1912.				
January	56		2,550	
February	56		2,400	
March	56		2,570	
April	56		2,430	
May	56		2,550	
June	56		2,400	
July	56		2,510	
August	56		2,480	
September	56		2,400	
October	56		2,480	
November	56		2,400	
December	56		2,480	
Total			29,650	

FULLERTON-BREA CANYON.

(Figures by Standard Oil Company.)

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1903				
January	99	------------	114,018	37
February	95	------------	106,400	40
March	88	------------	113,057	41
April	89	------------	108,000	40
May	90	2	108,926	39
June	96	3	112,362	41
July	100	4	119,477	39
August	109	5	129,208	38
September	110	3	131,940	40
October	119	2	128,712	35
November	121	5	128,910	35
December	126	2	126,725	32
Totals	------------	26	1,427,735	
1904				
January	128	3	126,920	32
February	131	3	123,860	34
March	134	------------	127,970	31
April	134	1	120,300	30
May	134	4	124,375	30
June	138	3	124,800	30
July	139	4	126,880	29
August	125	3	128,890	33
September	127	------------	113,050	30
October	106	3	109,553	33
November	130	------------	121,187	31
December	120	------------	119,652	32
Totals	------------	24	1,467,437	
1905				
January	120	------------	113,189	30
February	113	------------	99,676	32
March	119	------------	125,780	34
April	122	------------	121,850	33
May	122	------------	120,900	32
June	122	------------	114,000	31
July	123	------------	135,287	35
August	120	------------	127,100	34
September	138	------------	138,800	33
October	128	------------	136,400	34
November	132	------------	130,875	33
December	135	------------	141,050	34
Total	------------	------------	1,504,907	
1906				
January	136	1	142,600	34
February	135	1	127,400	34
March	136	------------	137,950	33
April	145	------------	139,350	32
May	145	2	144,150	32
June	147	------------	139,350	32
July	147	------------	143,995	32
August	147	2	150,040	33
September	147	2	144,000	33
October	149	1	156,550	34
November	151	------------	156,000	34
December	153	1	162,750	34
Totals	------------	10	1,744,135	

Fullerton-Brea Canyon—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1907				
January	154	3	162,750	34
February	155		148,400	34
March	155	2	161,200	33
April	160		206,100	43
May	161		204,100	41
June	168	1	199,900	38
July	170	2	203,400	39
August	171	5	202,850	38
September	175	2	221,500	42
October	177	1	244,500	45
November	178	2	230,500	43
December	180	1	239,500	43
Totals		19	2,424,700	
1908				
January	180	2	226,607	40
February	179	2	224,937	45
March	181	3	245,488	44
April	182	2	241,250	43
May	185	3	261,200	45
June	188	6	273,898	48
July	194	1	322,400	54
August	195	2	326,554	54
September	197	1	313,800	53
October	197		313,000	51
November	197	2	304,900	51
December	194	2	322,600	53
Totals		26	3,376,634	
1909				
January	197		338,130	55
February	198	2	304,293	55
March	200	1	333,493	54
April	200	5	347,654	58
May	205	1	357,804	56
June	207	1	362,391	58
July	207	2	369,460	58
August	208	5	339,330	53
September	211	2	363,180	57
October	212	3	378,004	57
November	217	5	377,639	58
December	221		399,583	58
Totals		27	4,270,967	
1910				
January	219	2	405,561	60
February	225	1	376,445	60
March	226	2	426,517	61
April	228	1	408,564	50
May	228	4	423,193	60
June	231	1	398,642	57
July	232	3	423,150	59
August	234	2	438,617	60
September	236	2	439,544	62
October	238	2	448,139	61
November	240	2	447,409	62
December	237	1	408,220	55
Totals		23	5,044,001	

Fullerton-Brea Canyon—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1911				
January	238	----------	396,169	45
February	238	3	362,109	54
March	240	4	436,084	59
April	245	1	483,898	52
May	248	4	574,338	65
June	254	3	577,945	76
July	254	1	576,684	73
August	256	2	562,965	71
September	257	4	517,803	67
October	262	----------	510,097	63
November	257	2	467,984	61
December	254	4	512,697	65
Totals	----------	28	5,978,773	
1912				
January	259	----------	540,187	67
February	264	1	503,262	68
March	261	2	532,679	66
April	263	5	533,183	68
May	269	1	538,236	64
June	269	1	530,214	66
July	272	1	562,297	67
August	272	4	576,233	68
September	276	4	625,604	75
October	280	3	603,340	70
November	283	2	582,311	68
December	286	2	636,814	72
Totals	----------	26	6,764,360	

WHITTIER-COYOTE, PUENTE AND FULLERTON-BREA CANYON.

Year	Wells producing	Number of wells completed during month	Monthly production barrels	Barrels per well per day
1913				
January	484	1	788,139	52
February	491	5	767,723	56
March	492	6	852,977	56
April	498	1	826,551	55
May	491	1	826,001	54
June	494	2	812,251	55
July	492	6	835,934	55
August	498	2	880,746	57
September	497	3	856,708	57
October	503	6	905,875	58
November	506	2	1,161,514	76
December	514	1	1,144,914	72
Totals		36	10,659,333	
1914				
January	514	1	1,144,923	72
February	510	3	1,022,140	71
March	506	5	1,136,088	72
April	517	5	1,044,450	67
May	528	4	1,163,833	71
June	525	8	1,213,140	77
July	535	1	1,274,875	77
August	549	5	1,195,484	70
September	553	6	1,100,370	66
October	556	7	1,293,537	75
November				
December				
Totals				

COMPANIES OPERATING IN LOS ANGELES FIELD.

Company	Wells operating	Gravity	Official address
Bemis, J. B.	2		1708 W. First st., Los Angeles.
British California Oil Co.	24	14	521 Douglas Bldg., Los Angeles.
Book, J. S.	3		Hotel Vendome, Los Angeles.
Book & Gano (Tyler Oil Co.)	18		959 Adobe st., Los Angeles.
Burson, E. W.	5		Fillmore, Ventura County.
Butler, Chas.	1		765 Kensington road, Los Angeles.
Clampitt, E. A.	29	15	Lake Shore and Patton st., Los Angeles.
Cooper Bros.	5		215 Welcome st., Los Angeles.
Davis, Frank	1		Court and Patton sts., Los Angeles.
Davidson, Chas. (operated by Industrial Oil Co.)	1		(Residence in state of Maine.)
Doran, Brouse & Price	17		537 I. N. Van Nuys Bldg., Los Angeles.
Dryden, Wm.	1		1071 W. Jefferson st., Los Angeles.
Gano, Henry	1		959 Adobe st., Los Angeles.
Graham Sisters	2		131 N. Union ave., Los Angeles.
Green, C. C.	3		811 S. Bonnie Brae st., Los Angeles.
Green, R.	9	15	811 S. Bonnie Brae st., Los Angeles.
Hansen, C. C.	2	15	856 N. Figueroa st., Los Angeles.
Harris Oil Co.	149	14	701 College st., Los Angeles.
Harrison & Davis	10		821 Hinton st., Los Angeles.
Industrial Oil Works (C. V. Hall)	5		705 Story Bldg., Los Angeles.
Johnson, H. T.	1		1622 Lockwood st., Los Angeles.
Joyce, T. F.	7	14	3901 W. Seventh st., Los Angeles.
Kohlmeyer, B.	1		1325 Rich st., Los Angeles.
Lapp & Gifford	3		303 Fay Bldg., Los Angeles.
Lick, Chas.	5		3770 S. Figueroa st., Los Angeles.
Los Angeles Railroad Co.	9		Pacific Electric Bldg., Los Angeles.
Manley, Mrs.	9	14	215 S. Grand ave., Los Angeles.
McCray, M. L. Oil Co.	16	14	225 S. Alvarado st., Los Angeles.
McGue, A.	1		2903 Hoover st., Los Angeles.
Mericos Oil Co. (Amalgamated Oil Co.)	7		424 Pacific Electric Bldg., Los Angeles.
Off Crude Oil Co.	3		First and Union sts., Los Angeles.
Pacific Coast Manufacturing Co.	2		126 S. Los Angeles st., Los Angeles.
Sanborn, Helen	2		690 S. Burlington ave., Los Angeles.
Shirley, I. W.	21		173 S. Burlington ave., Los Angeles.
Smith, G. H.	1		Long Beach, R.F.D. 2.
Suck, Leo	1		316 E. Second st., Los Angeles.
Westlake, Walter	2		980 Yale st., Los Angeles.
Whittier Consolidated Oil Co.	5		510 S. Spring st., Los Angeles.
Woolner Oil Co.	21		220 Story Bldg., Los Angeles.
Yarnell, Jesse	5		129 S. Bonnie Brae ave., Los Angeles.

Companies Operating in Salt Lake Field.

Company	Wells completed	Gravity	Official address
Amalgamated Oil Co.	6	16.5	Pacific Electric Bldg., Los Angeles.
American Petroleum Co.	9	15.0	602 Security Bldg., Los Angeles.
Arcturas	33	17.0	Pacific Electric Bldg., Los Angeles.
Gilmore, A. F.	20	15.5	625 Merchants Trust Bldg., Los Angeles.
Kansas Crude	2		
Pacific Light and Power Co.	44	14.5	
Rancho La Brea	54	12.5	Wright & Callender Bldg., Los Angeles.
Stephens	1	18.0	
Salt Lake	109	14.5	Pacific Electric Bldg., Los Angeles.
Union Oil Co.	8	--------	Union Oil Bldg., Los Angeles.
West Coast	14	16.5	
Total	300		

Companies Operating in Whittier-Fullerton Field.

Company	Location	Wells completed	Gravity	Official address
Amalgamated Oil Co.	13	11	--------	Pacific Electric Bldg., Los Angeles.
Amalgamated Oil Co.	24, 3S., 10W.	44	22	
American Petroleum Co.	--------	--------	--------	510 S. Spring st., Los Angeles.
Birch Oil Co.	2, 3S., 10W.	6	22	
Brea Canyon	1 and 2, 3S., 10W.	25	23	215 W. Sixth st., Los Angeles.
Brand & Stevens	24, 3S., 10W.			
Canadian Pacific	--------	22	19	
Colorado Oil Co.	--------	16	18	108 W. Sixth st., Los Angeles.
Central Oil Co.	--------	63	20.5	H. W. Hellman Bldg., Los Angeles.
Cornerstone Oil Co.	--------			
Calokla Oil Co.	19, 3S., 9W.	1	--------	456 S. Spring st., Los Angeles.
Coyote Hills Oil Co.	--------	--------	--------	610 S. Broadway, Los Angeles.
Columbia Oil Producing Co.	8, 3S., 9W.	23	19.5	307 W. First st., Los Angeles.
Columbia (Orange)	2, 3S., 10W.	3	22.0	
Columbia (Pico)	2, 3S., 10W.	1	23.0	
Columbia (East Puente) Olinda	9, 3S., 9W.	28	32.0	
Columbia Hills	34 and 35, 2S., 10W.	55	30.0	
Dorsby Oil Co.	19, 3S., 9W.	2	20.0	456 S. Spring st., Los Angeles.
Fullerton Oil Co.	9, 3S., 9W.	--------	29.5	
	2, 3S., 10W.	19	23.0	
General Petroleum Co.	8 and 9, 3S., 9W.			
	2, 3S., 10W.	35	19.0	Higgins Bldg., Los Angeles.
Home Oil Co. of Whittier	--------	16	18.5	
McAnders Oil Co.	24, 3S., 10W.			
Monte Christo Oil Co.	18, 3S., 9W.	--------	--------	544 Market st., San Francisco.
North American Cons.	19, 3S., 9W.	1	--------	80 Post st., San Francisco.
Olinda Land Co.	9, 3S., 9W.	9	15.0	104 N. Spring st., Los Angeles.
Petroleum Co.	24, 3S., 10W.	3	23.0	456 S. Spring st., Los Angeles.
Standard Oil Co.	--------	22	20.0	Standard Oil Bldg., San Francisco.
St. Helens	18, 3S., 9W.	2	19.0	Los Angeles.
Santa Fe	8 and 9, 3S., 9W.	70	20.0	Kerckhoff Bldg., Los Angeles.
Thomas Strain	24, 3S., 10W.	70	20.0	
Tri-State Oil Co.	8, 3S., 10W.	--------	--------	456 S. Spring st., Los Angeles.
Union Oil Co.	--------	55	18.5	Union Oil Bldg., Los Angeles.
West Coast	--------	9	19.0	Pacific Electric Bldg., Los Angeles.
Whittier Crude	--------	10	22.0	430 S. Broadway, Los Angeles.
Total	--------	551		

The amount of oil produced by various companies in 1913 is indicated by figures on pages 32, 33, 36, 42, 43 and 46.

Cost of producing or lifting oil from completed wells in the various fields near Los Angeles, is shown by the following accounts:

Puente Hills.

1 year, 49 wells (average 2,000 feet); 254,260 barrels.

Labor, pumping	$9,973 38
Labor, general	3,097 30
Labor, pulling and cleaning	3,233 16
Fuel	4,225 62
Rods (6,600 feet)	364 40
Pumps (78)	907 88
Supplies (hardware, etc.)	1,268 86
Belts	245 16
Repairs	2,233 91
Electric power	678 90
Water	518 31
Stable (auto and teams)	575 58
Freight	93 82
Miscellaneous	185 17
Total cost	$27,601 45
Cost per well day	1 54
Cost per barrel	108

Puente Hills. (1 year.)

Wells	20	29	3	35
Barrels	491,000	39,000	471,000	20,000
Depth	1500-2500	1500-2000		
Repairs	*$4,861 00	$2,033 00	$570 00	$1,529 00
Labor	16,638 00	6,531 00	6,706 00	9,117 00
Lubricants	627 00	533 00	466 00	426 00
Fuel	910 00	----------	----------	----------
Water	2,612 00	898 00	1,307 00	----------
Teaming	118 00	----------	4 00	----------
Miscellaneous	33 00	382 00	200 00	665 00
Total cost	$25,799 00	$10,377 00	$9,253 00	$11,737 00
Cost per well day	$3 53	$0 98	$0 845	$0 92
Cost per barrel	052	266	019	586

*Includes 54 pumps and parts, about $2,000.

Puente Hills. (1 year.)

	33 wells. Individual engine	16 wells. Two powers and jacks
Labor (pumping repairs)	$21,841 00	$821 00
Material	6,270 00	138 00
Totals	$28,111 00	$959 00
Cost per well day	$2 34	$0.164

Salt Lake Field. (1 month.)

53 wells, 1,500 to 1,600 feet; gas power.

Pumpers	$1,600 00
Pulling wells	1,060 00
Lubricants	350 00
Pumps and supplies	980 00
General repairs	980 00
Total	$4,970 00
Cost per well day	3 25

These figures show, as do those in other fields, the greater expense of pumping the heavier oil, due to the necessity of frequently replacing pumps and cleaning wells.

Cost of drilling in the Salt Lake Field with Standard tools is shown by the following account of a well 2,260 feet deep. (It will be noted that the fuel and water charges for drilling do not appear.)

Rig	$409 00
Rig irons	------
Rig building	175 00
Engine	266 00
Boiler (second-hand)	190 00
Pipe. 400 feet 3-inch	90 60
1,000 feet 2-inch	108 00
100 feet ½-inch	2 90
fittings	59 40
Belts	-----
Sump hole	75 00
Drilling.	
Labor	1.600 00
Depreciation tools	200 00
Wire line, 2,500 feet ⅞-inch	341 25
2,500 feet ½-inch	91 40
Casing, 14-inch S. P. 120 feet	150 00
14-inch shoe	14 00
10-inch 689 feet	971 49
10-inch shoe	23 65
8-inch 2,260 feet	2,960 60
8-inch shoe	15 26
Fuel, ½ ton coal	7 50
½ ton coke	8 00
Fishing.	
Cementing.	
Finishing.	
Tubing, 2,200 feet 3-inch	704 00
Rods, 2,200 feet ¾-inch	207 90
Barrel	2 50
Adjuster	11 00
Stuffing box	1 25
Total	$8,685 70
Total cost per foot	3 84
Casing cost per foot	1 83
Labor cost per foot	78
Working time	90 days
Rate per day	25.2 feet

The usual rate of drilling and amount of casing used is indicated by the following table of results at 115 wells.

Casing Record and Drilling Time, Salt Lake Field.

	Depth				Fifteen inches			
	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.
Less than 1,500 feet	68	1,253	1,535	1,021	10	118	178	89
1,500 feet to 2,000 feet	28	1,741	1,984	1,509	18	114	137	98
2,000 feet and over	19	2,435	3,226	2,006	13	126	200	100

	Twelve inches				Ten inches			
	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.
Less than 1,500 feet	56	121	357	74	53	511	750	360
1,500 feet to 2,000 feet	18	177	465	94	5	581	948	150
2,000 feet and over	2	149	165	133	16	938	1,383	335

	Eight inches				Six inches			
	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.
Less than 1,500 feet	63	832	1,420	200	15	500	1,479	59
1,500 feet to 2,000 feet	28	1,393	1,920	922	13	863	1,984	324
2,000 feet and over	18	1,545	2,909	566	9	908	2,960	55

	Drilling rate feet per day			
	Wells	Av.	Max.	Min.
Less than 1,500 feet	60	30.2	49.6	11.2
1,500 feet to 2,000 feet	24	24.9	35.2	12.1
2,000 feet and over	18	19.3	32.2	9.2

Summary of Casing and Labor Cost, Salt Lake Field.

	1,500 feet and less		1,500 feet to 2,000 feet		2,000 feet and over		
Number of wells and average depth	68 (1,253 feet)		28 (1,741 feet)		19 (2,435 feet)		Unit price (casing labor)
Rate of drilling (feet per day)	30.2 feet		24.9 feet		19.3 feet		
	Feet		Feet		Feet		Per foot
Casing, 15-inch	1,180	$1,475	2,052	$2,562	1,638	$2,045	$1 25
Casing, 12½-inch	6,776	10,367	3,186	4,880	298	456	1 53
Casing, 10-inch	27,083	40,624	2,905	4,357	15,008	22,512	1 50
Casing, 8¼-inch	52,514	68,268	39,004	50,705	27,810	36,153	1 30
Casing, 6¼-inch	7,500	6,750	11,219	10,157	8,172	7,355	90
Casing totals		$127,484		$72,661		$68,521	
Casing per foot		1.50		1.49		1.48	$18 00 per day
	days		days		days		
Labor totals	2,821	$50,778	195	$35,226	2,396	$43,128	
Labor per foot		.60		.72		.93	
Casing and labor totals		$178,262		$107,887		$111,649	
Casing and labor, per foot		2.10		2.21		2.41	

Cost of drilling in the Puente Hills with Standard tools is fairly shown by the following accounts of three wells:

	Depth		
	2,810 feet	2,900 feet	2,944 feet
Rig—			
Lumber	$1,325 00	$1,500 00	$494 00
Labor		----------	230 00
Irons		1,565 00	580 00
Engine	355 00	----------	653 00
Boiler	1,075 00	----------	----------
Drilling—			
Labor	7,700 00	6,452 00	4,679 00
Casing	10,227 00	10,433 00	11,599 00
Cable	2,983 00	3,293 00	3,003 00
Bull rope	79 00	54 00	50 00
Miscellaneous	5,000 00	5,000 00	5,300 00
Totals	$28,744 00	$28,297 00	$26,588 00
Total cost per foot	$10 22	$9 72	$9 02
Casing cost per foot	3 64	3 59	3 93
Labor drilling, per foot	2 74	2 22	1 58
Working time* (days)	428	358	468
Rate per day	6.7	8.1	6.3

*Working time computed from labor cost at $18 per day. Price of labor: driller, $5.50 per day (12 hours); tool dresser, $3.50 per day (12 hours).

In the Coyote Hills the following drilling costs were with combination tools at four wells. Standard tools were used only for entering the oil sand:

	Depth			
	3,257 feet	3,250 feet	3,270 feet	3,363 feet
Labor and supplies	$22,822 00	$24,434 00	$19,438 00	$26,958 00
Rig and tools	2,500 00	2,500 00	2,500 00	2,500 00
Total cost	$25,322 00	$26,934 00	$21,938 00	$29,458 00
Cost per foot	$7 76	$8 27	$6 64	$8 75
Working time (days)	90	100	120	105
Rate per day (feet)	36.2	32.5	27.2	32.0

Price of labor: 1 driller at $6 per day (12 hours); 4 helpers at $3 per day (12 hours). Fuel, 25 to 30 barrels per day at 90 cents to $1. Water, $1.50 per day Rotary; water, $1 per day Standard.

Comparison of the Puente and Coyote drilling costs is useful as the territory is similar: The Rotary tools are superior to Standard, not only on account of reduced cost but also on account of the speed at which the work is accomplished.

GEOLOGY OF THE SOUTHERN LOS ANGELES AND ORANGE COUNTY OIL FIELDS.

By Clarence A. Waring.

Introduction.

The geological information on the Los Angeles and Orange County oil fields is here presented (see Plate II), with the aim of enlarging the area previously known, by publications. It is the result of compilation of geologic maps, after several weeks spent in reconnoissance work throughout the territory and in making cross-sections through the Puente Hills. The base map is from topographic sheets published by the United States Geological Survey. Manuscript maps by R. N. Ferguson, together with his personal aid in the field, made it possible to cover considerable territory, besides that previously mapped around the Los Angeles and Puente Hills oil fields (U. S. Geol. Surv. Bulletin 309). For the information on the northern portion of the Santa Ana Mountains we are indebted to the Geological Department of the University of California for the use of their recent map of that area.

The detailed description of geology in the different fields has been gathered from field observations and from the former publications by Eldridge and Arnold (U. S. Geol. Surv., Bul. 309), Prutzman (California State Min. Bur. Buls. 32 and 63), and Watts (California State Min. Bur. Buls. 11 and 19, and Seventh Annual Report of the California State Mineralogist, 1887).

Location.

The area under discussion, in the general vicinity of the city of Los Angeles, is bounded by north-south lines through Santa Monica, Los Angeles County, and Rincon, Riverside County; and by east-west lines through South Pasadena, Los Angeles County, and Laguna, Orange County. It includes the Los Angeles and Salt Lake oil fields with westward extensions, and easterly and southerly possibilities; and the Whittier, Puente Hills, Brea Canyon, Fullerton (Olinda), La Habra and Coyote Hills fields, together with the Chino region and other possible territory surrounding them. The San Pedro and Newport regions, where some drilling has been done, are also included.

Topography.

The topography of the northern part of the general region consists of the great Los Angeles-Santa Monica terrace which extends southwestward with a gradually lessening slope, from the base of the Santa Monica Mountains and the Puente Hills, towards the coast. The northern and eastern boundaries of the terrace are marked by low hills, while along the coast to the west the San Pedro Hills are the only prominent rise in the topography. A low ridge extends from Los Cerritos Island to the Beverly Hills. The area is drained by the Los Angeles and San Gabriel rivers, which flow nearly due south and drain into San Pedro and Alamitos bays, respectively.

In the southern part of the area the mountains extend to the coast and bound and direct the drainage of the gently undulating area southeast of Santa Ana. The Santa Ana River flows southwestward and drains all the southern part of the region.

Because of the gentle slope of the terrace portion of the area the rivers and streams spread out, during the flood season, and deposit their sediments at a considerable distance from their ordinary channels.

General Geology.

The formations of the region consist of a base of granitic and metamorphic rocks overlain by Cretaceous, Tertiary, and Pleistocene sediments.

Igneous rock, metamorphic granite, gneiss and schist make up the Verdugo Mountains, San Rafael Hills, north end of the Puente Hills, and part of the northeast side of the Santa Ana Mountains. Rhyolite dykes and basaltic flows in places intrude all the pre-Pliocene sedimentary rocks.

Sedimentary. Upper Cretaceous (Chico) sediments are exposed only along the flanks of the granitic core of the Santa Ana Mountains. The formation here consists of a series of conglomerate, coarse sandstone and shale, overlain by interbedded sandstones, conglomerates and carbonaceous shales, in all a thickness of about 2,000 feet.

Eocene sediments in places overlie, unconformably, the Chico formation. The Eocene is represented by remnants of the Martinez and Tejon formations lying along the western exposure of the Chico. The Martinez consists of about 1,500 feet of fine grained gray and tan colored sandstone with some concretionary limestone. The Tejon consists of about 1,300 feet of medium grained gray and tan colored sandstone, carbonaceous shale and fossiliferous limestone, and coarse conglomerate.

Both the Cretaceous and Eocene strata are overlain, in places, unconformably, by the Vaqueros sandstone, or lowest member of the Monterey series.

Monterey Series. Monterey sandstone and shale cover considerable of the area in the San Joaquin Hills, and overlie unconformably the Cretaceous and Eocene sediments of the Santa Ana Mountains. Three formations, the Vaqueros, Monterey and Puente, are recognizable.

Vaqueros Formation. The Vaqueros formation as exposed in both these regions, consists of about 2,500 feet of indurated, iron-stained, granitic sandstone interbedded with sandy shale. Both the sandstone and shale are fossiliferous in places. Two miles northeast of Laguna specimens of *Pecten miguelensis* Arnold and *Scutella fairbanksi* Merriam were taken from the sandstone. One half mile south of Laguna Lake specimens of *Turritella sespeensis* Arnold were obtained from the sandy shale. This horizon is probably the upper Vaqueros.

Monterey Formation. At the top of the series of sandstones and shales of the Vaqueros formation is a conglomerate bed which is taken as the base of the Monterey (Temblor) sandstone formation which consists of about 1,500 feet of varicolored sandstone in which *Turritella ocoyana* with its associated fauna are found. Typical Monterey shale overlies the Monterey sandstone.

The same members of the Monterey series occur in the Santa Ana Mountains, where typical Vaqueros and Monterey fossils were collected. The formations of the region are readily correlated with the Monterey series in the Santa Monica Mountains.

Puente Formation. In the Puente Hills, the southern boundary of which is the Santa Ana River, and extending north and west to the southern base of the San Gabriel, San Rafael, and Santa Monica mountains, is a series of Miocene sandstones and shales which have been called the Puente formation (U. S. Geol. Surv. Bul. 309, pp. 103–105). The Puente series probably represents post-Vaqueros sedimentation throughout the region so mapped. It is the writer's opinion that continuous sedimentation took place in the Puente Hills and Los Angeles region throughout the Miocene, after which a period of erosion took place and the Fernando was deposited. The fauna of the lower Puente sandstone of Arnold from the Los Angeles district (U. S. Geol. Surv. Bul. 309, pp. 146–148) show this member to be upper Monterey. The lower shale of Eldridge in the Puente Hills is typical Monterey. The upper interbedded sandstones and shales of the Puente series which contain *Pecten pedroanus* Trask are believed to be the upper Miocene in this region, and the name Puente formation will be confined to these sediments. They may later be found to be a partial equivalent of the Santa Margarita and Jacalitos horizons of the San Joaquin and Salinas Valley region. The shales north of Eastlake Park overlie the heavy bedded Monterey sandstone and carry the fossil *Pecten pedroanus* Trask. These shales are the same as those exposed south of the park which carry the same pecten in a bed of fish spines. A section of the Puente along the cut where the Pasadena Short Line Railroad runs below the cement bridge on Macy near Gallardo street, shows 150 feet of shales and oil-bearing sandstone dipping S. 10° E. 45° overlain by 350 feet of maroon colored shale, which carries fish spines in a bed near the top. These are overlain unconformably by Pleistocene conglomerate. Specimens of *Pecten bellus* Conrad have been taken from the Dollar well (SW. ¼, Sec. 32, R. 1 S., R. 12 W.), and probably much of the region to the east is underlain by Fernando.

For a further and more complete discussion of the Monterey series the reader is referred to our description of the general geology of Ventura and northern Los Angeles counties.

Fernando. The Fernando formation consists of a series of conglomerates, sandstones and arenaceous clays which in places unconformably overlie the older formations. In much of the region it is difficult to distinguish between the shales of the Fernando and those of the upper Puente. The basal conglomerate of the Fernando is a good horizon marker and has been used, where possible, for the separation on the accompanying areal geologic map. Fossils are common in the upper sandstone of the formation along the southwestern side of the Puente Hills. Specimens have also been taken from the formation in the Los Angeles Field (U. S. Geol. Surv. Bul. 309, pp. 152–3), and from the Dollar well, four miles east of Los Angeles.

General Structural Features.

The dominant structural feature of the whole region is faulting. This has taken place along two general systems, one in a direction N. 80° E., and the other in a direction N. 60° W. To the first of these systems belong the Santa Monica fault, which runs along the southern face of the Santa Monica Mountains; the Los Angeles City oil field fault; and the Santa Ana River fault, which separates the Santa Ana Mountains from the Puente Hills. To the second system belong the Puente fault, which follows the southwest flank of the Puente Hills anticline; and the Newport fault, which extends along the coast north of Laguna. Minor faults which both parallel and cross the two major systems, give rise to great structural complications.

Folding and faulting have governed the topography of the region, and the two processes are responsible for structure favorable to the accumulation of oil in commercial quantities.

DETAILED GEOLOGY OF THE FIELDS.

LOS ANGELES CITY FIELD.

Location.

The accompanying geological map, Plate II, should be used in conjunction with the following discussion of the Los Angeles City Field. The productive portion of this field is confined, at present, to the wells east of Coronado street, with the exception of the block bounded by Commonwealth avenue and Fourth street, where there are twenty-one operating wells. It includes the Eastern field extending from Buena Vista street to Sunset boulevard, and the Central field extending from Sunset boulevard to Coronado street. The Eastern field at present has 221 operating wells while the Central field has 174. Of the total of 416 wells which operate intermittently, an average production of from two to three barrels per well per day is maintained. The oil averages about 14° gravity.

Geology.

The Central and Western fields are located along the south flank of an anticline in the Puente formation. The anticline is faulted from Sunset boulevard eastward and oil has accumulated in the sandstones and interbedded fractured Puente shale on the south side of the fault. The oil is contained in the Puente sands and has found passage to the surface along the fault.

Two sands have furnished most of the oil produced in the field. The upper sand is about 100 feet thick, while the lower sand, which is 300 feet stratigraphically below the upper sand, varies from forty to fifty feet in thickness. Other minor sands interbedded with the Puente shales furnish some oil.

The Western field is practically abandoned and the wells of the Eastern field are being gradually reduced to an uneconomic basis because of the advance of the water level. The wells south of the fault in the Eastern field promise to be productive for considerable time, since the oil sands appear to be more slowly depleted near the fracture.

Although prospecting east of Los Angeles River has so far developed no economically productive wells, it is possible that considerable oil underlies the region.

For geologic cross-sections through this field the reader is referred to U. S. Geol. Surv. Bul. 309, figs. 13 and 14, pp. 171–175, and to California State Mining Bureau Bul. 63, fig. 27, p. 199.

SALT LAKE OR SHERMAN FIELD.

Location.

The Salt Lake Field lies two miles south of the foot of the Santa Monica Range and about three miles west of Vermont avenue. It occupies about two square miles, and is named after the Salt Lake Oil Company, which was the first company to operate in the field.

Geology.

Although the geology of the area is obscured by alluvium and Pleistocene deposits of gravel, sand and clay, considerable has been learned by use of well logs in cross-sectioning the field. For sections through the field the reader is referred to California State Mining Bureau Bul. 63, p. 220, and to U. S. Geol. Surv. Bul. 309, fig. 17, p. 189. Cross-sections made by the writer through the field show several small folds along a northeast to southwest axis in the northwest corner of Section 22. In the west central part of Section 21, in a section N. 70° E. the oil sands dip about 15° to the northeast with several undulations; in a section N. 30° W. the oil sands undulate with a dip of 50° to the northwest.

The oil is taken from incoherent sands of probable late Miocene and Pliocene age, which are folded and faulted along a northeast-southwest axis. The productive portion of the field is limited, both to the north and south by faults along which seepages occur. The oil sands north of the fault approach the surface to the northeastern part of the field in sections 15 and 22. They dip to the southwest and are flexed into a minor anticline and broken north of Wilshire boulevard. Immediately south of the fault no wells of great economic importance have been developed. The oil sands have probably been either faulted up and lost, or faulted down out of reach of the drill.

The main oil zone, consisting of a series of thin productive sands interbedded with clayey and sandy shales, varies in thickness from 150 to 500 feet. The main oil sand is approximately 100 to 125 feet thick, is coarse grained, and is highly impregnated with oil and gas. The depth at which the sands lie depends on the location of the wells in relation to the dip of the strata. The oil varies in gravity from 12.5° to 18° B.

The district claims the deepest well in California. The Rosemary well of the Union Oil Company was drilled to a depth of 5,594 feet on the Brashear tract, near the center of Section 28, T. 1 S., R. 14 W. A Standard rig was used and the hole was reduced to 4½ inches when abandoned in 1910. A small quantity of oil was found at the surface, and it is said some oil was found at the bottom of the hole, which is in shale.

The field is practically all drilled up. It is limited to the north by the fault near the granite of the Santa Monica Mountains, to the south by the La Brea fault, and to the east by the outcrop of the oil strata. Development work to the west seems to have disproved the territory adjacent to the field.

Wells surrounding the Salt Lake Field, the results of which are worthy of consideration in outlining possible future productive oil territory, are as follows:

Company	Location	Depth	Results
A. H. Denker wells	Sec. 12, 1-15	520′	Tar, sulphur, water, gas.
Northwest Oil Company	Sec. 12, 1-15	600′±	Abandoned.
Grador	Sec. 18, 1-14	Deep	Little oil.
McDor	Sec. 18, 1-14	Deep	Some oil. Abandoned.
American Petroleum	Sec. 18, 1-14	#9, 1,100′	Abandoned.
Gilmore	NW. corner NE. ¼, Sec. 20, 1-14	1,700-1,900′	Tar. Too heavy to pump. Abandoned.
Rancho La Brea	N. ½ SW. ¼, Sec. 15, 1-14	260-600′	Oil, 11°-12° B., and water. Abandoned.
Rhodes wells	W. ½ SE. ¼, Sec. 15, 1-14		
Lombard, B.	E. ½ Sec. 29, 1-14	600′±	Abandoned.
Pico Oil Company	SE. ¼ Sec. 29, 1-14	822′	Show of oil. Abandoned.
Amalgamated "Rodeo"	E. line Sec. 29, 1-14	723′	Show of oil.
Clark & Sherman Land Co.	E. line Sec. 29, 1-14	120-521′	Some oil from 50′ to 150′.
Ida Hancock Tract	NW. ¼ Sec. 28, 1-14		Heavy oil.
Hardison, McFarland & Stewart	North end of Hancock strip	1,780′	Dry. Casing pulled.
Union Oil Company, "Massalin"	NW. ¼ Sec. 28, 1-14	900-3,000′	Some heavy oil.
Union Oil Company, "Rosemary"	NE. ¼ Sec. 28, 1-14	5,594′	Some oil.
Joyce, T. R.	NW. cor. Sec. 27, 1-14	1,800′	Heavy oil.
Mansfield, S.	NE. corner Sec. 28, 1-14 NW. ¼ Sec. 27, 1-14		Some heavy oil.
Rommel Oil Company	F. Rampau Estate, NW. ¼ Sec. 27, 1-14	750-1,000′	Small amount of 22° oil reported.
Rosedale Cemetery Ass'n	SE. ¼ Sec. 28, 1-14	120-800′	Some 16° oil. Abandoned.
Mansfield, W. H.	W. line Sec. 33, 1-14	550′	Some oil and gas. Abandoned.
Thomas, H. C.	SE. corner Sec. 32, 1-14	175-654′	Some heavy oil. Abandoned.
Hauser Tract	NW. ¼ Sec. 33, 1-14	230-355′	No oil, sulphur water.
Keating Tract	E. ½ Sec. 33, 1-14	1,256′	Trace of oil. Abandoned.

BEVERLY HILLS FIELD.

Location.

Two miles west of the Salt Lake Field several wells have been drilled on a southeastern spur of the foothills of the Santa Monica Mountains. This group of wells, called the Beverly Field, is located in the southeastern corner of Rancho San Jose de Buenos Ayres and in the western part of Rancho Rodeo de Las Aguas. The ridge on which these wells are drilled rises less than 100 feet above the plain and intersects the axis of the Salt Lake group one half mile north of where the wells are drilled.

Geology.

The ridge on which the Beverly wells are drilled is anticlinal with an axis running approximately N. 40° W. It is probably the northern end of the low ridge which passes just east of Inglewood and extends southeastward through Howard Summit, Dominguez Hill and Los Cerritos. Sections made through the field (see Fig. 68) show the main oil zone

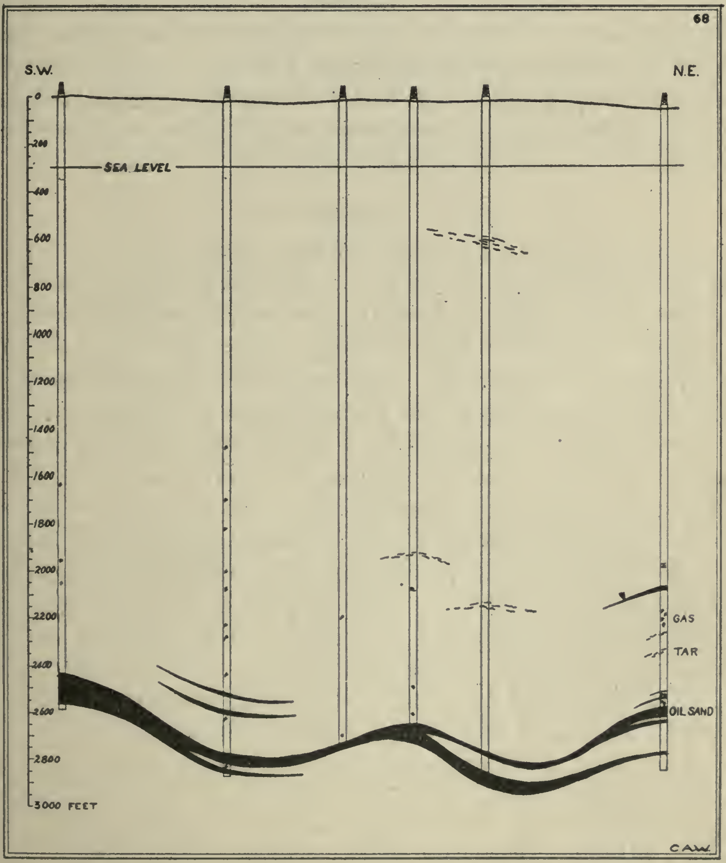


Fig. 68.—Section N. 25° E. through the Beverly Hills Field.

to lie between two and three thousand feet below the surface. The structure does not consist of one continuous anticline, but of several small folds which tend to scatter the accumulations of oil and necessitate more wells. The formations passed through consist principally of shale and hard beds of limey sandstone. The water is mostly above 550 feet and is shut off just above the oil sands.

Only three companies are operating in the field. The Amalgamated Oil Company has seven producing wells along the southwest boundary of its Rodeo lease; all wells northwest of this line of wells have been abandoned. The West Coast Oil Company has eight producing wells in the east central part of the Wolfskill lease and two in the northeastern corner of the Gillis lease. The Kansas Crude has two wells. The limits of the field may possibly be extended both northwest and southeast along the axis of folding, although the abandoned wells probably disprove some of the land.

WHITTIER FIELD.

Location.

The productive territory of the Whittier Field lies on the southern slope of the Puente Hills, beginning within a mile of the town of Whittier and extending in a S. 65° E. direction about two and one half miles. It covers about nine tenths of a square mile of proved territory in Sections 22, 23, and 26 of T. 2 S., R. 11 W.

Geology.

The Whittier Field consists of a belt about one half mile wide, developed along the southwest side of the Puente fault zone. Oil has been obtained principally from the Fernando formation which covers the region south of the fault and dips nearly due south at an angle varying from 45° to vertical. The Fernando is badly faulted and fractured. The oil horizons of the Fernando are dependent upon the contact of its various conglomeritic and sandy beds with the Puente shales which lie both north of the fault and unconformably beneath them. These horizons are higher lithologically in the Fernando in the eastern portion of the field, due to a greater displacement of the beds to the east. The wells are deeper the farther they are located from the fault, down the dip of the strata. Wells drilled north of the fault in the Puente series have obtained a little oil from the sandstone layers interbedded with the shales. Some heavy oil has been obtained, both from the Puente shales and from the crushed strata along the fault zone, but most wells producing oil in commercial quantities have been located far enough south of the fault to tap the oil strata at depths ranging from 800 to 2,500 feet, where oil of from 15° to 22° B. is obtained. The reader is referred to the geologic sections (California State Mining Bureau, Bul. 63, p. 249, and U. S. Geol. Surv., Bul. 309, pl. XI, Secs. A-B and C-D) formerly published, for any additional information on the geologic structure of the field.

PUENTE FIELD.

Location.

The Puente Field lies about six miles S. 75° E. of the Whittier Field and follows near the crest of the Puente Hills anticline. The field covers about three tenths of a square mile of proved territory in the east central part of Sec. 34 and the west central part of Sec. 35, of T. 2 S., R. 10 W.

Geology.

The wells of the Puente Field have all been drilled near the axis of the Puente Hills anticline into Monterey shale and the interbedded and underlying oil sands which are probably of Temblor and Vaqueros age, respectively. The axis of the anticline has a direction slightly south of east and plunges a little in the same direction. The shale is overlain to the north by Puente sandstone; while to the south, the main flank of the anticline is full of minor folds which become less steep towards the edge of the prairie. The depth to the oil-bearing sands varies from 800 to nearly 2,000 feet; their thickness varies from a few inches up to 100 feet. The gravity of the oil varies from 26° to 35° B.

For geologic sections through this field the reader is referred to U. S. Geol. Surv. Bul. 309, pl. XI, Sec. E-F. Development of the field has followed the line of the suspected fault and unconformity to the east. The western end of the field is limited by the pitch of the anticline, which would necessitate too deep drilling.

BREA CANYON FIELD.

Location.

The Brea Canyon oil field lies S. 50° E. of the Puente oil field, and south of the Puente fault zone. It takes in about three tenths of a square mile of proved territory on either side of La Brea Canyon where that canyon cuts along the axis of a faulted anticline in the Fernando formation. The field lies in the west central part of Sec. 1 and the east central part of Sec. 2, of T. 3 S., R. 10 W.

Geology.

The wells of La Brea Canyon Field tap the oil sands of the Fernando formation, which is faulted down against the Monterey shale and sandstone to the north. Just south of the Puente fault, which follows the Monterey-Fernando contact, is apparently a small fault caused by a sharply folded anticline in the Fernando formation. Seepages occur along the secondary fracture, and wells have been developed on its flanks. The beds on both sides of the anticlinal axis dip from 50° to 90°.

Development to the north is theoretically limited by a line south of the Puente fault where the wells pierce the oil strata at a depth great enough to obtain oil light enough to pump. To the south the field is limited by a line at which the oil strata lie too deep to reach profitably with the drill. To the west the Fernando is eroded away, barring the underlying Monterey, while to the southwest all the Tertiary formations are covered with alluvium. The field is joined, by scattering wells, to the Fullerton-Olinda Field which lies to the southeast.

The oil sands outcrop near the northwest quarter of Sec. 1 and dip to the southwest. Several sands have been found at depths varying from 500 to 2,000 feet below the surface on the northwest quarter of Sec. 1, and from 1,700 to 2,600 feet at the west end of the proved territory. The oil from these beds has a gravity varying between 21° and 30° Baumé. A deeper sand, encountered in two or three wells at depths ranging from 3,000 to 4,000 feet, yielding a lighter oil under high gas pressure.

For a geologic section through this field the reader is referred to U. S. Geological Survey, Bulletin 309, Plate XI, Sections I-J.

FULLERTON-OLINDA FIELD.

Location.

The Fullerton-Olinda oil field lies three miles S. 70° E. of La Brea Canyon Field and at the end of the Santa Fe branch line which terminates at Olinda. It embraces approximately one and four tenths square miles of proved territory lying south of the Puente fault in the southwest corner of Sec. 6, the north half of Sec. 7, nearly all of Sec. 8, and a strip through the central part of Sec. 9, in T. 3 S., R. 9 W.

Geology.

The geology of the Fullerton-Olinda Field is very complex. The axis of the main Puente anticline which trends approximately N. 70° W., lies less than a mile north of the oil belt. Faulting has brought the Monterey shale and sandstone up into contact with the Fernando formation. Folding is intense in the region along the fault and the fracturing of the rock has no doubt been a great factor in the accumulation of oil.

The wells in the field obtain oil from both the Monterey sandstones and the Fernando formation. Wells drilled north of the fault along a syncline in the interbedded Monterey sandstone and shale, obtain a light oil ranging in gravity from 22° to 35° Baumé, at depths ranging between 600 and 3,100 feet.

There is apparently no correspondence between the depth and the productiveness of these wells. They vary materially from location to location because of the crumpled character of the beds.

The portion of the field drilled into the Fernando formation yields oil varying from 18° to 22° Baumé at depths ranging between 750 and 2,800 feet.

Three or more oil sands, varying from 200 to 400 feet apart, furnish the oil for these wells. The lower sands carry a higher gravity oil.

LA HABRA OIL FIELD.

Location.

The La Habra oil field lies two miles S. 40° W. of the Olinda Field. It embraces about one square mile of territory in the southeast corner of Sec. 13 and the north half of Sec. 24 of T. 3 S., R. 10 W., also the south half of Sec. 18 and the north half of Sec. 19 of T. 3 S., R. 9 W. This field is a comparatively new development, some of the land being highly valuable for agricultural purposes, the oil wells being drilled amid orange groves. It is not the same as the La Habra Canyon Field in Sec. 30, T. 2 S., R. 10 W. described by Eldridge (U. S. Geological Survey, Bulletin 309, pages 115 to 117), in which the wells have all been abandoned.

Geology.

The section, Fig. 69, shows the geologic structure of the La Habra

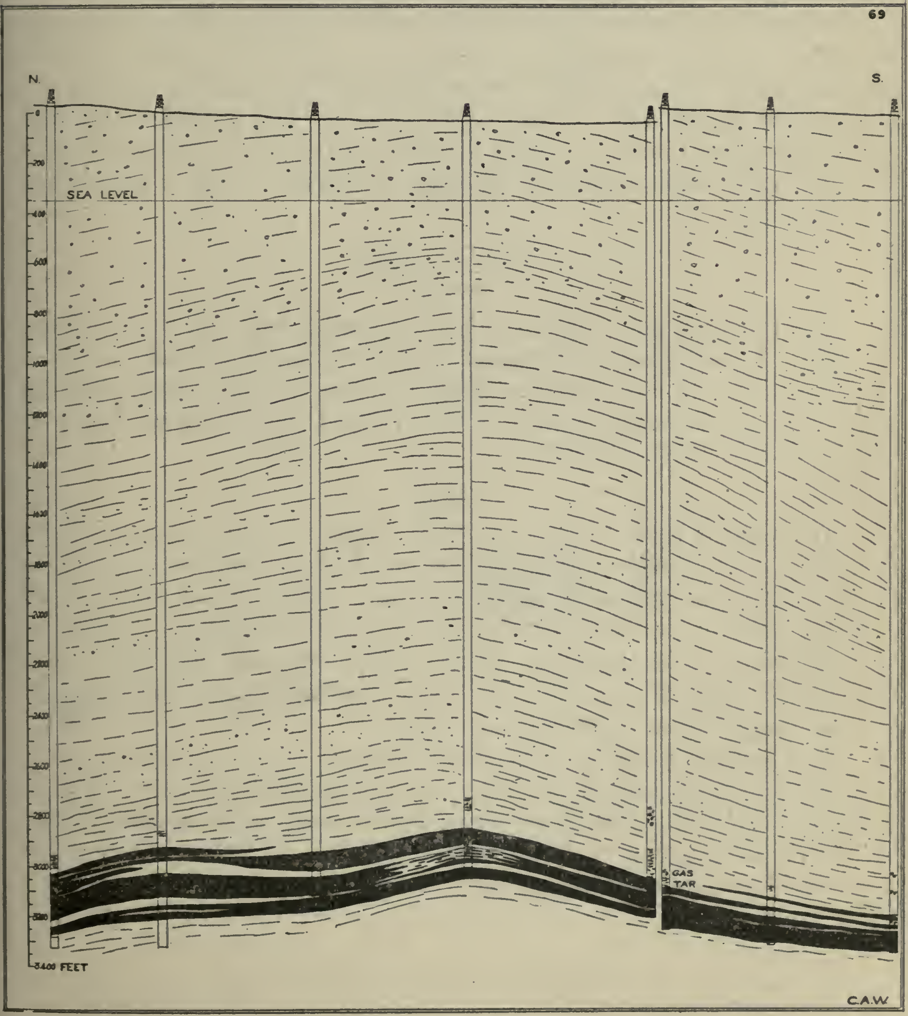


Fig. 69.—North-South cross-section through La Habra Field, showing oil sands.

Field. The oil is obtained along an unsymmetrical anticline in rocks probably of Fernando age. The formation is covered by alluvium but is probably a continuation of that in Brea Canyon. The axis of this anticline runs east and west, and pitches gently towards the west.

The rock drilled through consists mostly of shale and hard sandstone. The oil sands are struck at depths ranging from 2,900 to 3,300 feet, depending upon the location of the well with respect to the anticline. The oil sands are in places over one hundred feet thick and yield considerable gas with the oil, the gravity of which ranges from 18° to 23° Baumé.

Possibilities of extension of the field to the east and west remain to be proved. Deep wells drilled about one mile both east and west on the anticline have been dry holes, and possibly disprove that territory. The sands may be lens-shaped and barren to the east and west, or the anticline may plunge both east and west, forming an elongated dome in the region of successful development. Abandoned wells as shown on the map hint towards the limits of the field but development has not gone far enough yet to definitely determine. The present active rate of development should, within a year or two, pretty well define this field which might easily be expected to double or triple its present proved area.

COYOTE FIELD.

Location.

The Coyote Field is located about five miles due west of La Habra Field. It includes approximately eight tenths of a square mile of proved land in the southeast corner of Sec. 13, the south half of Sec. 18, the southwest corner of Sec. 17, and the northwest corner of Sec. 19 in T. 3 S., R. 10 W.

Geology.

The Coyote Hills Field is probably located on the same anticlinal axis as the La Habra Field. The economically productive territory is at present confined to the region from one quarter to one half mile on either side of the axis of the anticline, but the field may possibly be extended to twice this size. Wells drilled both east and west of the territory mapped as proved have been abandoned and probably show that the sands are barren in that region.

The geological cross-section, Fig. 70, taken across the anticlinal axis, shows the structure of the field. The wells strike the oil sands at approximately the same level when drilled along a line parallel to the axis of the anticline in the formation which is probably a continuation of the Fernando southeast of the Whittier Field.

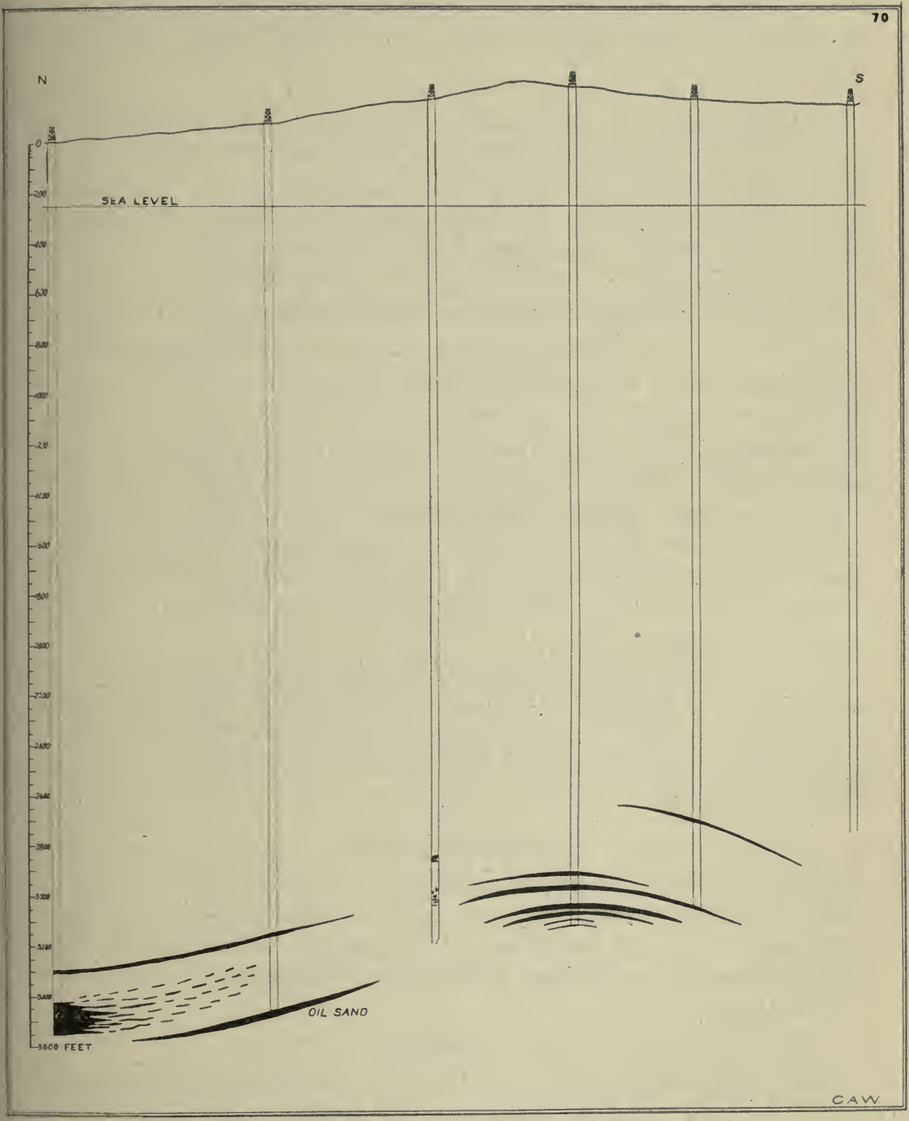


Fig. 70.—North-South cross-section through the Coyote Field.

BURREL POINT REGION.

Location.

Burrel Point is a prominent point of land south of the Santa Ana River, which extends from the Santa Ana Mountains in a westerly direction. It terminates just north of the town of Olive.

Geology.

The north flank of Burrel Point is covered with sandstones and clays of the Fernando formation which overlies the Monterey sediments exposed along the north side of Santiago Creek. An anticline with axis running N. 70° W. passes through the Point. It is possible, that Santiago Creek follows the foot of a fault scarp, the north being the upthrust side.

Two wells have been drilled for oil on Burrel Point. One of these went to a depth of 3,300 feet and was abandoned and cemented. The formations passed through were shale and sandstone. Some gas was encountered between two and three thousand feet, and tar at about two thousand feet. Another hole is being drilled one eighth of a mile farther to the north.

A well is reported (California State Mining Bureau, Bulletin 63, page 334) to have been drilled by the Orange County Oil Company in the bed of Santiago Creek at a point a short distance east of where it emerges from the hills. This well was 700 feet deep and is said to have shown traces of oil.

So far as known these are the only wells drilled south of the Santa Ana River, and should oil be found on Burrel Point it would be reasonable to drill farther to the east into the northward dipping monocline of the Monterey series where it is overlain by Fernando on the north flank of the ridge.

CHINO REGION.

Location.

By the Chino Region is meant all that territory lying along the northeastern flank of the Puente Hills, and extending from the Santa Ana River northward to the head of Chino Creek which bounds it on the northeast.

Geology.

The geology of the region consists of a northeasterly dipping monocline of upper Miocene sediments. Numerous exposures of the oil sands are to be found along the ridge to the southwest. In places the late Miocene sediments are overlain by Fernando conglomerate.

A few wells drilled near the region under discussion, in the valley east of Chino Creek, are reported to have struck tar sands. The wells of the Chino Land and Water Company, in Sec. 32, T. 2 S., R. 8 W., are located along an outcrop of the oil sands in the axis of an anticline. The wells were from 900 to 1,000 feet deep and made a little heavy oil but were abandoned because unprofitable. The well of the Chino Valley Beet Sugar Company in Sec. 30, T. 2 S., R. 8 W., is also reported to have encountered a little oil between 440 and 465 feet.

A well is being drilled in Telegraph Canyon, back of Slaughter's Ranch, in Sec. 2, T. 3 S., R. 8 W. The location is on Griffin's Ranch on a lease by Garrett and Watson. The well is probably located below the oil horizon represented by the sands outcropping farther to the north.

In the whole region the sands are near the surface and probably lack sufficient covering to have prevented loss of the lighter elements of the oil. It is improbable that oil will be found in the region unless it should occur in beds lower than those exposed and drilled into up to the present time.

NEWPORT REGION.

Location.

By the Newport Region is meant all the territory lying between Newport Beach and El Toro. It is bounded on the north by the southern end of the prairie region. The San Joaquin Hills continue southeastward about five miles south of the area considered.

Geology.

The geology of the region really consists of an eastward extension of the formations and structure found along the southwestern flank of the Santa Ana Mountains to the east of El Toro. The formations represented are those of the Monterey series, moderately folded along a northwest-southeast axis. A fault parallels the coast about one-half mile inland.

Tar seepages occur in several localities where it issues from the fractures in the Monterey shale. In no place has the shale been observed to have interbedded sandstones, nor to be sufficiently capped by proper strata to form oil reservoirs.

The Vaqueros and Temblor sandstones everywhere underlie the Monterey shale.

Wells drilled northeast of Newport and southwest of El Toro in search of oil have passed from the thin Pleistocene and alluvial capping directly into the Monterey shale. Only small amounts of heavy oil were encountered and the wells necessarily abandoned.

SAN PEDRO REGION.

Location.

The San Pedro Region is isolated from the oil fields of the Los Angeles and Puente Hills districts by the broad Los Angeles plain. It lies southwest of the Beverly Hills Field and is bordered on the east and southwest by the coast line.

Geology.

The main part of the San Pedro Hills is made up of Monterey shale intensely folded and faulted, and intruded by diabase. It is probably underlain by rocks of the Franciscan series, for glaucophane schists are exposed at the heads of several of the canyons near the summit. A fault, with direction N. 50° W., enters the southwestern coast at a point about a mile and one half northwest of Point Fermin.

Along the eastern coast the Monterey shale is overlain by late Miocene, Pliocene, and Pleistocene sediments which, in order, dip at angles varying from 30° to 5° towards the east. These sediments extend from one half to one and one half miles inland and flank the hills.

A few wells have been drilled on the north side of the San Pedro Hills into the Monterey shale, but only heavy oil in small quantities has been obtained. Other wells have been drilled near the town of San Pedro on the east flank of the hills but no oil of economic importance was struck.

In the bluff on the west side of Point Fermin the Monterey shale, dipping S. 10° E. 17°, is overlain unconformably by 200 feet of heavy bedded blue and brown sandstone, made up of Franciscan material, largely chert and schist pebbles. About 75 feet of this sandstone, which dips S. 20° W. 8°, is impregnated with oil. This exposure of oil sand extends along the coast east of Point Fermin and may be the outcrop of economically important oil sands underlying the sea to the south. In making a more detailed geological survey of the region, the fault should be given due consideration.

CONCLUSION.

In summing up the relations of geology to the accumulation of oil in the southern Los Angeles and Orange County oil fields, consideration of two processes is all important. These are, faulting and folding.

The oil apparently has its origin in the diatomaceous shales of the Monterey series. The presence of faulting and fracturing in the Los Angeles, Salt Lake, Whittier, Puente, Brea Canyon, and Fullerton (Olinda) fields indicates that this process is necessary to furnish the oil with passages along and into the factured shales and sandstones.

Where anticlinal structure is present in the overlaying formations it makes a particularly favorable combination of structure for oil accumulation. Thus the oil is not only brought within the reach of the drill, but is provided with structure favorable for its accumulation in quantities of economic importance.

The importance of folding is perhaps most noticeable in the Beverly Hills, La Habra and Coyote fields (see Plate II). The anticlinal structure in these fields appears to be the factor which has determined oil accumulation. Whether fracturing has accompanied the folding can not be positively determined, but it is improbable since the folding is so gentle. Where water, in place of oil, is found at the oil horizon along the flanks of anticlines, the folding will determine the extent of fields.

The gravity of the oil is not so greatly dependent, as has been formerly supposed, on the depth at which the oil sands are struck. Several factors influence the gravity. Exposure of the oil to atmospheric conditions after its origin is probably important. The extent of exposure of an oil to atmospheric conditions depends upon the structural conditions and character of the formations in which it occurs. These can only be surmised by the geologist after taking all possible factors into account.

The results obtained by the following outlying wells is worthy of consideration in outlining possible future productive oil territory:

Southern Los Angeles and Orange County.

Company	Location	Depth feet	Remarks
Currier	Sec. 17, 2 S. 9 W.	3,500	Drilling; trace of oil.
Harbor Crude Oil Company	Sec. 27, 4 S. 14 W.	3,865	Abandoned; some heavy oil.
Pitt Oil Company	Sec. 28, 4 S. 14 W.	------------	Rig up.
Yorba Oil Company	2 miles east of Stern	1,600	Gas. Drilling.

CHAPTER VIII.

VENTURA COUNTY.

Small and entirely separate oil fields are a characteristic of Ventura County.

Some of the earliest development efforts in California were made in Ventura County, where the numerous seepages of oil were quite evident. Earlier than 1854 Andreas Pico knew of the oil seepages at Pico Canyon, and with a copper still and worm, made oil in a small way for the San Fernando Mission.

Attention was not given to geologic conditions and some of the first work about 1864 was disappointing. Among the first records of careful examination of California oil prospects is the published report of S. F. Peckham, made in June, 1866 (Geological Survey of California, Vol. II, Appendix, pp. 47-73). The wonderfully clear insight of that writer into both geological and commercial conditions is most amazing. At the time of his visit there had been produced and shipped a total of 3,078 barrels in the course of ten months. Most of this production came from tunnels and seepages and the operators were conservatively advised to stick to that form of development, although a few wells were even then yielding a slight amount of oil. The final paragraph of that early publication is worthy of repetition if for no other reason than to drive home the importance and value of accurate observations by a trained man. It must be remembered that his remarks applied only to land he had actually examined, between Point Concepcion and Cañada de Brea.

''The expectation of extraordinary results, that will admit of comparison with those that have been produced in Pennsylvania, must be set aside without the shadow of a hope to rest upon. The expectation of a fair return and a permanent profitable investment may be reasonably entertained; and the application of capital upon this basis to the development of this interest will make it of great importance to the State, and of unequaled importance to that particular section in which the bituminous outcrops occur.''

In 1874 there were several localities in Ventura County where oil was being produced from springs or ''natural sources.'' (Henry Degroot, Fourth Annual Report of the State Mineralogist, 1884, pp. 293–308.) Practically the only consumer of the crude material was the Central Pacific Railroad, which used two hundred barrels a month for lubrication.

In 1875 three shallow wells were drilled with spring poles at Pico Canyon (Los Angeles County) and actual development with steam machinery began in 1877. By 1884 the Pacific Coast Oil Company at Pico Canyon, was producing from sixteen wells about 560 barrels of oil daily. A two-inch pipe line carried the oil to their refinery at Newhall. The company owned another refinery at Alameda Point, on San Francisco Bay, being at that time the most extensive and successful oil operator on the Pacific coast. This property, many years later, was the first California holding of the Standard Oil Company. There were four other companies producing oil in 1884, among them being the Mission Transfer Company, which was a beginning of the Union Oil Company. The pioneer work was frequently discouraging, it being estimated that previous to 1881 as much as $1,000,000 had been lost, due to blind prospecting without scientific guidance. Stewart & Hardison alone had invested $130,000 without return.

In 1887 there were thirty-one completed wells at Pico Canyon, twenty of which were producing 491 barrels daily. In the vicinity of Sulphur Mountain there were various wells producing a total of 142 barrels per day, and some seventy-five miles of two-inch pipe collected the oil at Santa Paula, whence about eighteen miles of four-inch line carried it to Hueneme for sea shipment. The oil was all handled by the Mission Transfer Company, while Hardison & Stewart were among the chief producers. A drilling outfit cost about $3,000, and the average cost of a completed well 1,000 feet deep was $10 per foot (W. A. Goodyear, Seventh Annual Report of State Mineralogist, 1887, pp. 101–114).

In 1895 the number of producing wells in Ventura County was forty-seven, with a total monthly yield of 4,290 barrels. There were also over thirty tunnels with a total monthly yield of 1,048 barrels. (W. L. Watts, Bulletin 11, California State Mining Bureau, 1896, pp. 38–45.) Eleven producing concerns contributed to the total yield. Most of the oil was handled by the Union Oil Company by a four-inch pipe line extending to Ventura. The Pico Canyon property (Los Angeles County) produced 150,000 barrels per year from about thirty-five wells.

In 1900 W. L. Watts enumerated 267 completed wells in twenty-one groups; of these 172 were producers. The annual production figure for Ventura County therefore showed an average per well per day of a little over seven barrels.

The rate of development and production in Ventura County since 1903 is shown by the diagram (Fig. 71) made up from figures by the Standard Oil Company. The annual production and price since 1894 is shown in the table of the State Mining Bureau figures. From 1903 until the middle of 1909 the reports show a variable number of wells, usually about 200, with a regular monthly production of about 30,000 barrels, or five to six barrels per well day. Since the middle of 1909

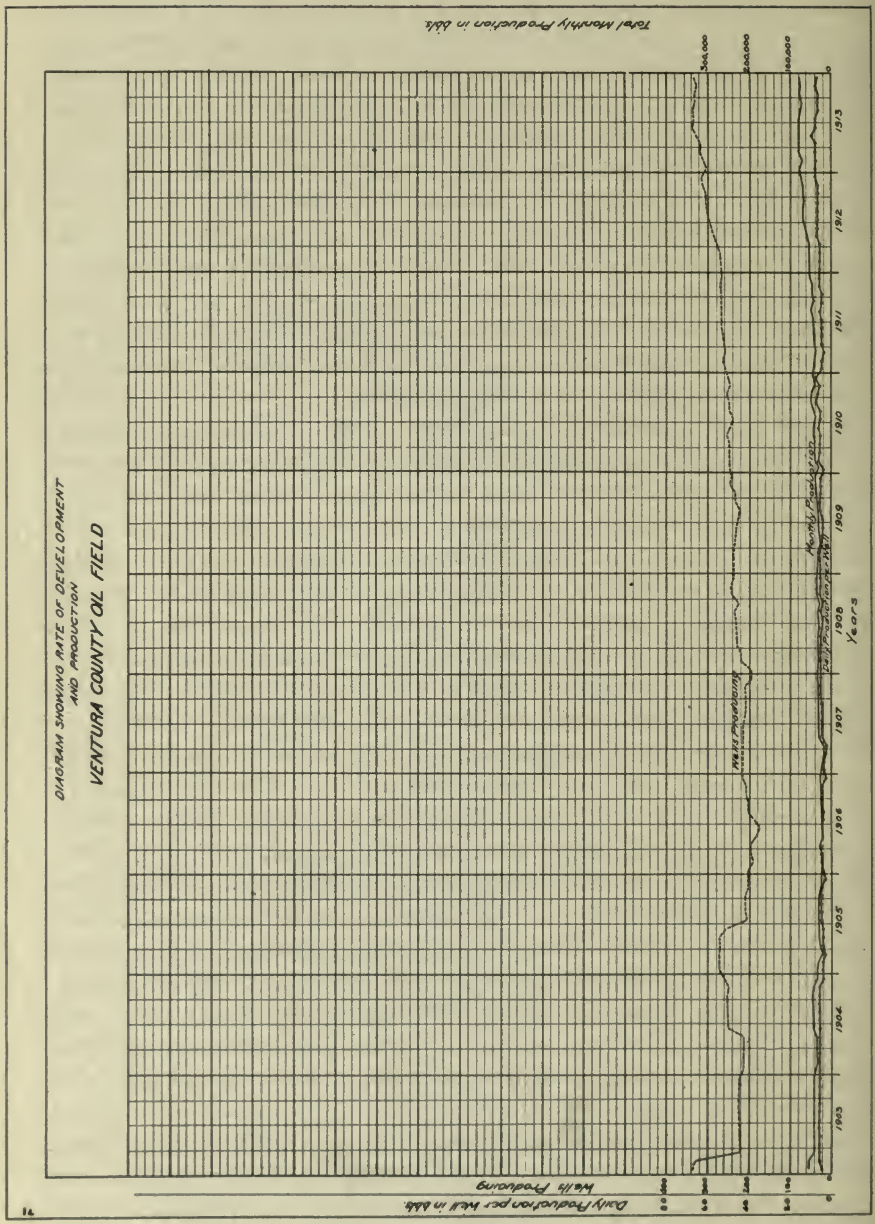


DIAGRAM SHOWING RATE OF DEVELOPMENT
AND PRODUCTION
VENTURA COUNTY OIL FIELD
Total Monthly Production in bbls.
300,000
200,000
100,000
0
Wells Producing
Daily Production per Well in bbls.
80 400
60 300
40 200
20 100
0
Monthly Production
Daily Production per Well
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
Years

Fig. 71.

there have been new wells at the rate of about 29 per year and the monthly production has steadily increased to about 75,000, or an average per well day of about eight barrels. The Montebello property is the most active and largest producer at present.

An idea of the productiveness of new wells in virgin ground may be gained from the monthly statistics by assuming that the production from old wells since 1909 has been about 31,000 barrels per month, and using the number of recently completed wells, which gives the following result:

December, 1909	5 wells at 56 barrels per day
June, 1910	11 wells at 35 barrels per day
December, 1910	26 wells at 15 barrels per day
June, 1911	34 wells at 10 barrels per day
December, 1911	47 wells at 14 barrels per day
June, 1912	71 wells at 15 barrels per day
December, 1912	92 wells at 15 barrels per day
June, 1913	118 wells at 13 barrels per day
December, 1913	128 wells at 11 barrels per day

These figures show a rapid initial decline and agree pretty well with the statements of persons familiar with the productiveness of Ventura County wells (also W. L. Watts, Bulletin 19, State Mining Bureau, pp. 96–101).

Life of wells, according to the diagram, may be expected to be many years (possibly 25 or 30). As the various groups of wells are entirely separated and have no effect upon each other and prospecting in intervening ground is the greatest factor in enlarging the production, the diagram offers but little basis for speculation as to future production. New developments, in this neighborhood particularly, should only follow thorough examination by skilled geologists. No general rule can be applied.

Oil Production and Price, Ventura County.

(Since 1894.)

Year	Barrels	Price per barrel
1894	290,913	$1 26
1895	244,624	1 00
1896	248,000	1 10
1897	368,282	1 00
1898	427,000	1 34
1899	496,200	1 00
1900	443,000	90
1901	472,057	50
1902	475,000	96
1903	542,902	95
1904	518,000	90
1905	375,522	63
1906	311,000	50
1907	352,224	60
1908	289,625	75
1909	344,419	65
1910	492,147	65
1911	499,082	70
1912	662,300	88
1913	899,007	1 01

Ventura County.

(Figures by Standard Oil Company.)

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1903.				
January	338		55,800	5
February	333		54,500	6
March	223		43,214	6
April	224		41,820	6
May	224		43,214	6
June	225		42,000	6
July	225		43,400	6
August	225		43,400	6
September	225		42,000	6
October	225		43,400	6
November	226		42,000	6
December	226		43,400	6
Total			538,148	
1904.				
January	214		38,750	6
February	214		34,800	6
March	214		37,200	6
April	214		36,000	6
May	214		37,200	6
June	252		46,500	6
July	255		48,050	6
August	256		48,670	6
September	255		48,000	6
October	255		49,600	6
November	251		46,500	6
December	263		35,085	4
Total			506,355	
1905.				
January	276		37,200	4
February	276		34,720	4
March	277		23,250	3
April	272		30,500	4
May	273	1	31,451	4
June	258		31,110	4
July	208		31,310	5
August	211		34,255	5
September	211		31,860	5
October	212	1	30,460	5
November	205		27,750	5
December	205		28,678	3
Totals		2	372,544	
1906.				
January	205		27,750	4
February	193	1	27,070	5
March	199		30,055	5
April	199		31,200	5
May	184		26,330	5
June	173		26,100	5
July	194		26,160	4
August	205		28,160	4
September	205	1	28,860	5
October	210		30,432	5
November	210		28,560	5
December	218		30,185	3
Totals		2	340,862	

Ventura County—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1907.				
January	218		28,252	4
February	218		26,696	4
March	218		21,892	3
April	218	2	21,680	3
May	217	1	30,645	5
June	219		30,690	5
July	216	1	31,560	5
August	200		30,535	5
September	201		30,150	5
October	201		31,775	5
November	213	3	30,900	5
December	199		34,255	5
Totals		7	349,030	
1908.				
January	198	1	33,015	5
February	223		30,392	5
March	223		32,023	5
April	233		31,740	5
May	232		33,573	5
June	233	1	30,540	4
July	233	1	30,938	4
August	239	1	34,658	5
September	228		29,790	4
October	245	1	35,433	5
November	249	3	35,640	5
December	240		36,053	5
Totals		8	393,795	
1909.				
January	240	1	35,743	5
February	241	1	32,284	5
March	241	2	34,348	5
April	235		27,690	4
May	230	1	28,765	4
June	230		31,940	4
July	226	1	31,456	4
August	221		32,930	5
September	233	1	33,330	5
October	232	1	37,940	5
November	245	1	39,825	5
December	243	1	39,750	5
Totals		10	406,001	
1910.				
January	247	1	29,975	4
February	247		38,875	6
March	248		40,730	5
April	247	2	37,790	5
May	252	2	42,680	5
June	244	1	41,559	6
July	238		37,167	5
August	248	3	41,584	5
September	249	5	50,832	7
October	254	1	47,612	6
November	245	4	39,958	5
December	250	2	43,385	7
Totals		21	492,147	

Ventura County—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1911.				
January	259		42,999	5
February	264	3	40,402	5
March	257		35,256	4
April	259	1	40,707	5
May	261	3	40,945	5
June	266	1	41,853	5
July	266	1	41,874	5
August	267	1	48,366	6
September	267	4	42,476	5
October	266	3	45,018	5
November	269	1	44,972	6
December	266	3	50,807	6
Totals		21	515,675	
1912.				
January	267	2	51,224	6
February	269	4	51,320	6
March	270	1	52,828	6
April	277	8	53,465	6
May	284	3	58,852	7
June	290	6	63,582	7
July	297	4	67,816	7
August	297	6	67,366	7
September	303	2	64,036	7
October	301	4	67,943	7
November	310	3	68,232	7
December	313	2	73,509	8
Totals		45	740,173	
1913.				
January	302	4	75,006	8
February	310	3	69,745	8
March	318	6	77,886	8
April	316	5	77,434	8
May	329	7	79,112	10
June	336	1	77,593	8
July	331	3	78,925	8
August	335	1	73,115	7
September	330	3	70,272	7
October	330		75,379	7
November	326	2	73,250	8
December	332	1	74,556	7
Totals		36	902,273	

Ventura County and Newhall.

1914.				
January	409	1	85,715	7
February	394	1	61,684	6
March	385	1	65,999	6
April	403	3	85,380	7
May	405	4	89,342	7
June	411	6	87,150	7
July	419	3	92,845	7
August	428	3	84,568	6
September	425	1	82,140	6
October	425	1	79,639	6
November				
December				
Totals				

Newhall and Pico.

(Figures by Standard Oil Company.)

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1903.				
January	59	----------	10,590	----------
February	59	----------	10,612	----------
March	59	----------	11,825	----------
April	59	----------	11,675	----------
May	59	----------	11,368	----------
June	63	----------	13,140	----------
July	64	----------	12,884	----------
August	64	----------	12,772	----------
September	64	----------	12,240	----------
October	64	----------	12,276	----------
November	64	----------	12,030	----------
December	64	----------	12,625	----------
Total	----------	----------	144,037	
1904.				
January	65	----------	12,400	----------
February	65	----------	10,875	----------
March	65	----------	12,224	----------
April	67	----------	12,458	----------
May	67	----------	12,298	----------
June	65	----------	12,678	----------
July	66	----------	12,983	----------
August	65	----------	12,619	----------
September	65	----------	12,022	----------
October	65	----------	11,765	----------
November	65	1	11,111	----------
December	63	----------	10,991	----------
Totals	----------	1	144,424	
1905.				
January	63	----------	11,536	----------
February	63	----------	10,383	----------
March	60	----------	9,612	----------
April	60	----------	9,487	----------
May	62	----------	9,933	----------
June	62	----------	9,090	----------
July	62	----------	7,567	----------
August	62	----------	7,657	----------
September	62	----------	7,117	----------
October	54	----------	7,638	----------
November	54	----------	7,170	----------
December	54	----------	7,164	----------
Total	----------	----------	104,354	----------
1906.				
January	54	----------	6,990	----------
February	54	----------	6,134	----------
March	54	----------	6,405	----------
April	53	----------	5,413	----------
May	53	----------	5,367	----------
June	53	----------	5,277	----------
July	53	----------	5,334	----------
August	56	----------	5,922	----------
September	52	----------	5,118	----------
October	32	----------	3,528	----------
November	37	----------	3,577	----------
December	44	----------	4,452	----------
Totals	----------	----------	63,517	

Newhall and Pico—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1907.				
January	46		4,209	
February	51		4,426	
March	66		5,999	
April	67		5,878	
May	62		8,556	
June	63		7,864	
July	66		8,385	
August	68		9,418	
September	68		8,070	
October	65		7,923	
November	65		7,917	
December	64		7,909	
Total			86,554	
1908.				
January	64		7,997	
February	64		7,275	
March	65		8,969	
April	65	1	7,701	
May	65	1	8,312	
June	66		9,491	
July	67		7,916	
August	66	1	9,735	
September	67	1	8,664	
October	64		9,732	
November	66		9,429	
December	68		8,909	
Totals		4	104,220	
1909.				
January	67		8,683	
February	65		7,662	
March	63	1	7,108	
April	66		8,720	
May	66		7,922	
June	65	1	7,666	
July	69		7,955	
August	71		9,723	
September	67		11,315	
October	67		11,392	
November	69	1	9,993	
December	70		12,476	
Totals		3	110,618	
1910.				
January	67		10,933	
February	64		10,315	
March	66	1	12,072	
April	67	1	12,697	
May	70		14,188	
June	69	1	13,697	
July	70	1	15,864	
August	71	2	14,613	
September	71	1	14,901	
October	72	1	11,673	
November	76		14,468	
December	77	1	15,007	
Totals		9	160,428	

Newhall and Pico—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1911.				
January	77	----------	13,701	----------
February	76	----------	11,270	----------
March	76	----------	12,898	----------
April	76	----------	12,403	----------
May	76	----------	13,020	----------
June	76	1	12,072	----------
July	77	1	13,294	----------
August	78	----------	12,020	----------
September	78	----------	11,576	----------
October	78	----------	12,062	----------
November	78	----------	11,389	----------
December	67	----------	10,405	----------
Totals	----------	2	146,110	
1912.				
January	67	----------	9,096	----------
February	67	----------	9,750	----------
March	78	----------	11,070	----------
April	78	----------	10,828	----------
May	67	----------	9,572	----------
June	78	----------	10,649	----------
July	78	----------	10,662	----------
August	78	----------	9,706	----------
September	78	----------	9,568	----------
October	77	----------	9,672	----------
November	78	----------	9,094	----------
December	78	----------	10,045	----------
Total	----------	----------	119,712	
1913.				
January	78	----------	9,384	----------
February	67	----------	7,800	----------
March	67	----------	8,514	----------
April	78	----------	9,057	----------
May	73	----------	9,764	----------
June	73	----------	8,896	----------
July	76	----------	9,908	----------
August	76	----------	11,024	----------
September	76	----------	12,126	----------
October	76	1	11,485	----------
November	77	----------	10,671	----------
December	77	----------	11,150	----------
Totals	----------	1	119,779	

Financial results in the Ventura County Fields during the year 1913, as shown by twenty-one companies, producing 656,171 barrels of oil from 181 wells, are summarized as follows:

Capital. This figure can not be definitely determined, particularly the second item (property value) and any error here is apt to be on the side of an overestimate.

Cash paid for stock	$1,016,254 00
Property paid for stock	4,550,464 00
Total	$5,566,718 00

Dividends are difficult to determine as many concerns are close corporations, making no public reports, hence our figures may be slightly below the actual amounts. Records earlier than 1909 were not available:

1909, one company	$11,790 00
1910, one company	22,067 00
1911, two companies	46,252 00
1912, two companies	26,393 00
1913, two companies	54,720 00

Other facts are shown in table on page 10.

Drilling-cost of a shallow well (603 feet) in Ventura County is illustrated by the following figures. A Standard rig was used until completion, then dismantled except for light line and crown block for pulling and cleaning the well:

Lumber, nails, etc.	$263 25
Labor (including dismantling)	225 00
Fittings	43 57
Labor	716 64
Teaming	123 44
Tools (including depreciation)	267 20
Cordage (including depreciation)	56 17
Casing, 121 feet 8¼-inch	86 45
Casing, 507 feet 6⅝-inch	282 38
Casing sundries	31 86
Power and water	202 85
Oil, waste and packing	12 08
Sundries	89 70
Finishing	15 00
Tubing, 593 feet 2-inch	85 10
Pump and rods	48 08
Total	$2,548 77
Total per foot	4 21
Labor per foot	1 54
Material per foot	2 67

Companies Operating in Ventura County Fields.

Company	Location—Section, township and range	Wells completed	Gravity	Official address
Aloha Oil Co.	--------	14	15	
Anaconda Petroleum Co.	28-5-19	1	--------	811 H. W. Hellman Bldg., Los Angeles.
Bard O. and A. Co.	17 and 18-4-21	23	18	819 Story Bldg., Los Angeles.
Bardsdale Crude	12-3-20	8	24	Bardsdale, Cal.
Beatty O. and D. Co.	--------	1	--------	
Bell Oil Co. (Lapp-Gifford)	12-3-20	4	--------	
Big Chief Oil Co.	5-5-19	1	17.5	
Big Sespe Oil Co.	23 and 26-5-20	2	21	
Boulder Creek L. and O. Company	24-4-19	1	--------	906 Higgins Bldg., Los Angeles.
Calumet Oil Co.	3-3-19	4	31	218 Security Bldg., Los Angeles.
Capital Crude	16 and 17-4-21	16	20	637 Consolidated Realty Bldg., Los Angeles.
Combined Oil Co.	21 and 22-4-22	1	--------	
Calabasas Oil Co.	22-2-18	1	--------	
California Counties	7-3-23	1	--------	58 Sutter st., San Francisco.
Colonia of Oxnard	17-4-18	3	--------	
Concord Petroleum Co.	6-5-19	1	--------	1 Madison ave., New York.
Cosmopolitan Oil Co.	33-5-19	3	35	
Diamond Valley	9-4-18	1	--------	5 E. Central ave., Redlands.
Dabney & Roberts	--------	--------	--------	
Delta Star	33-5-19	6	--------	
Empire Oil Co.	13, 14, 18 and 24-4-20	11	36	637 Consolidated Realty Bldg., Los Angeles.
Emslie Oil Co.	6-4-19	3	26	
Forest City National	20 and 21-4-21	14	27	Santa Paula, Cal.
Fleisher	9-4-21	--------	--------	
Harris Oil Co.	13 and 14-4-19	10	--------	
Henderson	30-9-33	7	27	
Hidalgo Oil Co.	--------	--------	--------	
Hillside Crude	8-4-21	1	--------	
Hill Top Oil Co.	7-4-21	1	--------	Santa Paula, Cal.
Kimball	--------	--------	--------	
Montebello Oil Co.	6-3-19	60	34	801 Alaska Commercial Bldg., San Francisco.
Modelo Oil Co.	7 and 8-4-18	10	28	
Mutual Oil Co.	33-5-19	1	--------	
Miley & Buley	--------	--------	--------	
New Moody Gulch Oil Co.	8-5-19	1	--------	
Ojai Oil Co.	12-4-22	5	17	622 Bumiller Bldg., Los Angeles.
Ojai Valley Petroleum Co.	11-4-22	4	--------	605 Delta Bldg., Los Angeles.
Oak Ridge	14-3-21	1	--------	801 Alaska Commercial Bldg., San Francisco.
Oil Creek Oil Co.	35-5-19	1	--------	
Palmer Union	23 and 26-9-33	5	--------	609 Crocker Bldg., San Francisco.
Paula Oil Co.	22-4-21	2	22	
Pyramid Oil Co.	17 and 18-4-21	17	17.5	933 Phelan Bldg., San Francisco.
Pacific Petroleum Co.	--------	--------	--------	
Petrol Oil Co.	36-3-18	4	35	Insurance Bldg., San Francisco.
Piru Monarch	15, 16 and 21-4-18	1	20°-38°	305 Security Bldg., Los Angeles.
Pappose	--------	--------	--------	
Red Rock Oil Co.	25-4-22	1	--------	
Ramona Home	13-4-18	--------	--------	835 H. W. Hellman Bldg., Los Angeles.
Redman	--------	--------	--------	145 Second st., San Francisco.
Salt Marsh Canyon	30-4-21	4	25	
Square Oil Co.	--------	8	--------	
Santa Maria Crude	12-4-22	1	17	622 Bumiller Bldg., Los Angeles.

Companies Operating in Ventura County Fields—Continued.

Company	Location—Section, township and range	Wells completed	Gravity	Official address
Santa Susana Syndicate	30-3-17 36-3-18	7	35	Hollingsworth Bldg., Los Angeles.
Scarab Oil Co.	32-3-18	1	17	517 Consolidated Realty Bldg., Los Angeles.
Security O. and D. Co.		3		
Sespe Consolidated	36-5-20	4	12	519 H. W. Hellman Bldg., Los Angeles.
Shell Petroleum Co.		3	24	725 Title Ins. Bldg., Los Angeles.
South Mountain Oil Co.				
South Pacific	32 and 33-4-18	14	25	637 Cons. Realty Bldg., Los Angeles.
State Consolidated Oil Co.				916 Trust and Savings Bldg., Los Angeles.
Stockholders Oil Co.	17-5-19	1		
Sunset Oil Co.	12-4-19	5	15	820 H. W. Hellman Bldg., Los Angeles.
Santa Clara O. and D. Co.	13-4-20			719 Story Bldg., Los Angeles.
Sky Ranch				
Tepesquet				718 Merchants Exchange Bldg., Los Angeles.
Traders Oil Co.				Union Oil Bldg., Los Angeles.
Union Oil Co.	12-3-20	97		
Ventura Consolidated	30-3-17	5		319 Story Bldg., Los Angeles.
Ventura County Power Co.	12-3-24	9		
Ventura Pacific				
West Huasna	1-3-20	2	15	
White Star	33-5-19	11	34	401 Douglas Bldg., Los Angeles.
Winnipeg Oil Co.		2		
Wood, F. O.	10-3-20	1		

The amount of oil produced during 1913 is indicated by figures on pages 33, 36.

Companies Operating in Newhall Field.

(Los Angeles County.)

Company	Location—Section, township and range	Wells completed	Gravity	Official address
Clampitt Bros.	7-3-15 12-3-16	21	17	
Los Angeles Kern O. and M. Co.	4-3-15			612 H. W. Hellman Bldg., Los Angeles.
New Castaic				429 Douglas Bldg., Los Angeles
Standard Oil Co.	1 and 2-3-17 16, 17 and 22-3-16 7-3-15	64	33	Standard Oil Bldg., San Francisco.
Squaw Flat	18-3-15	1		210 Stimson Bldg., Los Angeles.

GEOLOGY OF THE VENTURA AND NORTHERN LOS ANGELES OIL FIELDS.

By Clarence A. Waring.

Location.

The area under discussion covers that territory in Ventura and northern Los Angeles counties, bounded by meridians 118° 30′ and 119° 20′ and by parallels 34° 12′ and 34° 29′ of north latitude. It includes all the wells drilled between the Santa Monica Mountains on the south and the Topa Topa Range on the north; and between north-south lines through Newhall on the east and Ventura on the west.

Topography.

The topography of the area is governed by folding and faulting. The Santa Clara River drains the steep and rugged country of the Topa Topa Mountains, to the north, and the Santa Susana Mountains and Oak Ridge to the south. It carries the waters to the west where they spread out over the broad Oxnard Terrace. The southern part of the area is drained by the Arroyos Simi and Las Posas which carry their waters to the west, running parallel to the Santa Clara Valley. The northwestern part of the region is drained by the Ventura River which receives the waters from Matilija Creek and the Ojai Valley and carries them almost due south to the ocean, emptying just west of Ventura. The geologic formations of the entire region are intensely folded, and the alternation of hard and soft Miocene sediments offers an erosional surface which cuts into steep canyons and sharp ridges, making the mountainous portion of the country very difficult of access.

GENERAL GEOLOGY.

Introduction.

The geology of the Santa Clara Valley and adjacent territory has been so fully covered by Peckham (Geology of California, Volume II, 1882), Watts (California State Mining Bureau, Bulletin 11), Eldridge (U. S. Geological Survey, Bulletin 309), and Prutzman (California State Mining Bureau, Bulletin 63) that it is not thought necessary to do more than restate the geologic descriptions in a general way and to systematize the various formation classifications. Most of the geological discussion will deal with the newly mapped territory west of Nordhoff and south of the area mapped by Eldridge (U. S. Geological Survey Bulletin 309, Plate 1). In general the country is so badly faulted and folded that the geological structure is not favorable for the continuity of oil sands. For this reason there is no possibility of the whole area being productive, and it has been thought best to make a brief statement, where possible, of the geology of each district, or group of wells. These will be taken up in order from the Ventura River eastward on the north side of the Santa Clara River and then south and westward on the south side of the Santa Clara River. The statistics on the productiveness of the territory (pages 371–374) will explain why the time allotted to examination of this territory was short as compared with other fields. The productiveness of undeveloped territory can only be determined by detailed geological work in the immediate vicinity of the area to be prospected. Public institutions are not ordinarily provided with sufficient funds to do such detailed work.

The map (Plate III) of the region, is compiled from several sources. The geologic contacts of the Santa Clara Valley region are taken from U. S. Geological Survey, Bulletin 309, Plate 1. The geologic description north of Arroyo Simi and south of Oak Ridge, between a north-south line, through Rocky Peak on the east, and Epworth on the west, was contributed by Messrs. R. B. Moran and J. O. Lewis. South of Santa Susana, to an east-west line through Conejo Mountains and westward from Simi to Somis, the geology was mapped by the writer, partly during private research work in the fall of 1913, and partly during the summer of 1914, while engaged in the present work, as was also the region east of a north-south line through Rocky Peak. We are indebted to Dr. J. C. Branner of the Stanford University Geological Survey for the use of an unpublished geologic map of the Ventura quadrangle, which was valuable in drawing some conclusions as to the economic importance of that territory.

Geologic Formations.

Geologists realize that many of the rock formations of one oil field extend into other oil fields. In many cases these formations have been given different names in different fields, because of a lack of correlative data. In compiling a map which includes two or more fields in which different formational names have been used, it has been necessary to delve into correlations which concern the State as a whole. All former publications have been given due consideration and the first formational name published has been given precedence. It is hoped that this classification will be a step towards further simplification of the present nomenclature. Multiplicity of geologic names tends to confuse every one and offers a productive field for the activity of charlatans and so-called ''experts'' who injure the reputation of a valuable science.

Chico Formation.

The Chico formation consists of about 3,500 feet of heavy-bedded, fine-grained sandstones which are well exposed in the Simi Hills. Chico fossils have been found in the lower part of this formation near the Ventura-Los Angeles County boundary line, one mile north of Bell Canyon, west of Canoga.

Martinez Formation.

The Martinez formation is exposed in this region only at the east end of the Simi Valley on the north and south sides. To the southeast it overlies, unconformably, the Chico sandstone of the Simi Hills. On the south side of the valley, where a cross-section was made, the formation consisted of 1,650 feet of conglomerate, shales and buff fossiliferous sandstone. The sandstone member contains *Venericardia planicosta* Lamark and *Turritella martinezensis* Gabb.

No oil is known to be obtained from the Martinez formation, although certain shales exposed south of Santa Susana may possibly carry oil at depth.

Tejon Formation.

The Tejon formation overlies the Martinez formation, apparently conformably. On the south side of the Simi Valley it consists of about 2,000 feet of sediments. The base consists of drab-colored shales, throughout which are concretionary limey sandstone beds containing numerous specimens of *Turritella pachecoensis* Stanton. Overlying the shale are drab-colored sandstone beds which contain numerous specimens of *Meretrix horni* Gabb. The remainder of the series consists of chalky shale, drab-colored sandstone, conglomerate, and shale. The upper shale contains some interbedded fossiliferous sandstones with *Meretrix horni* Gabb, *Turritella uvasana* Gabb and *Turritella andersoni* Dickerson. The fauna of the upper part of the formation mapped as Topa Topa (U. S. Geological Survey, Bulletin 309) has been found to be identical with that of the Tejon from the San Joaquin Valley Region, so the name Tejon has been used for all upper Eocene sediments throughout this publication.

The Tejon formation covers a large area in the northwestern part of the region, and is the chief constitutent of the Topa Topa Range. It is made up of about 3,500 feet of interbedded sandstones and shales, and as here used includes all sediments to the base of the Sespe red beds. The lower part of the formation consists of rusty brown and gray sandstone and sandy shale with included quartzites and concretionary brown sandstone. Poorly preserved fossils are sparsely found throughout. Quartzites are common near the middle, while sandstones and shales are interbedded in the upper part of the formation.

About one and one half miles north of the area mapped in Sespe Creek, Mr. H. Hannibal has found *Venericardia horni* Gabb associated with a large species of *Ostrea*. If, as he says, these fossils are in the formation mapped by Eldridge as lower Sespe, then the white oil-bearing sandstones below the red beds are of Tejon age. They are so shown on the accompanying geologic map.

If economic conditions make it possible, in later work, it will probably be wise to give the different facies of the Topa Topa series (U. S. Geological Survey, Bulletin 321, Plate 1) distinct formational names as has here been done with the Monterey series. Perhaps the name Topa Topa formation should be confined to the two lower facies, while the name Tejon formation should apply to the two upper facies of the Topa Topa series as divided in U. S. Geologic Survey, Bulletin 321, Plate 1.

The shales at the base of the Tejon formation are thought to furnish the oil obtained from the wells north of Santa Susana. North of the Santa Clara River the Tejon is not known to carry oil in commercial quantities, but it may furnish the oil found in the overlying Sespe formation.

Sespe Formation.

Sespe formation was a name used by Watts (California State Mining Bureau, Bulletin 11, pages 25 and 26) in 1897 for the brownstone sediments exposed in Sespe Creek. In 1907 Eldridge (U. S. Geologic Survey, Bulletin 309, pages 8 to 12) extended the name to cover both the whitish oil-bearing sandstones below and the rusty calcareous sandstones above the red beds.

The lower member of this series has been shown (see Tejon formation) to be of probable Tejon age, while the upper member is here included in the Vaqueros formation since it does not properly belong with the Sespe red beds.

About two miles south of the north edge of the area mapped, and one quarter of a mile west of Sespe Creek, Mr. H. Hannibal has found large specimens of a *Turritella,* closely allied to *T. inezana,* associated with a large species of *Ostrea.* These fossils probably show the Miocene age of the red beds and their close relationship to the Vaqueros formation which lies apparently conformably above it.

The ''Sespe red beds'' is probably the only lower Miocene formation which has not been, at one time or another, referred to as a part of the Monterey series, although its close kinship to the Vaqueros has apparently been recognized. Since we as yet have no evidence that the Sespe red beds are Oligocene, they are here mapped in the same general color as the Miocene formations with which they are so closely related, both paleontologically and lithologically.

The Sespe red beds carry oil near the mouth of Sespe Creek and also north of Sisar Creek. Near Sespe Creek the oil is thought to have entered the Sespe formation from the underlying Tejon formation, while north of Sisar Creek it may have been derived from both the Tejon and the Monterey shale.

The Monterey Series.

Much has been written on the Monterey series of California, the culmination of which was Louderback's Review (Bulletin Department of Geology, University of California, Volume 7, No. 10, pages 177 to 241) in 1913. Writers have recognized that the Monterey series consists of alternating sandstones and shales which were deposited during a geological time interval of sufficient length to cause a nearly entire change of fauna. It has been shown that the sandstones often grade into shales and vice versa, but no sliding scale in the nomenclature for mapping these formations has so far been suggested. The future of geological work lies in the specialization and definition of the different members of the geological series already named. To be content in leaving the Monterey series as one big unit, as Louderback suggests, is against all laws of progression.

When we consider that the term Monterey formation, as named by Blake (Pac. R. R. Survey, Vol. 5, Plate II, Chapter XIII, page 331, 1856) and used by Lawson (Bulletin Department of Geology, University, Vol. 1, pages 22 to 29, and Vol. 2, No. 12, pages 363 to 371) did not include all which some later geologists have made it include, it is readily seen that it is time to limit the term to some definite horizon so that it means something more than merely lower Miocene. The term Monterey has been almost as badly abused as the term Vaqueros, simply because the earlier geologists lacked that definiteness which has come to mean so much in later geological work. No slur is cast on the work of the early geologists by this statement for it is realized that their limited time demanded a more or less general classification of the geological formations.

If now we take the latest definition of the United States Geological Survey (given by the Twentieth Century Edition of the Standard Dictionary) for a formation ''a subordinate member of a group or series, distinguished by mode or origin, or lithological or paleontological differences'' we can readily see that each lithological or paleontological unit (each shale and sandstone facies), of the Monterey series could, legitimately, be given a separate formational name. Considering, however, the fact that shales of the Monterey series do grade into sandstones and vice versa in the same lithological unit, it is here proposed to use the following system, which can be added to or dismembered, without confusion, to cover the needs of any district.

Since, as geologists admit, the different sandstones and shales of the Monterey series, in a given district, can not be distinguished by lithology, we must naturally distinguish the subordinate members (the formations of the series) upon paleontological evidence. The different sandstone and shale facies of the formations thus established can be distinguished by varying the legend used in mapping.

The Monterey series of California, so far as present evidence shows, can be divided into three formations, the Vaqueros, Monterey, and Puente. These names are here restricted as follows for the coastal oil fields.

The Vaqueros formation includes all those sandstones and shales lithologically above the Sespe (red beds) or some other older formation, and the Monterey or some other more recent formation. The sandstone facies carries the fauna of the *Turritella inezana* zone (as described by J. P. Smith, Journal of Geology, Vol. 18, pages 216 to 226, 1910) and any shales overlying this zone or its shale equivalent are to be considered as belonging to the Monterey or some other more recent formation.

The Monterey formation includes all shales and sandstones lithologically above the Vaqueros or some other older formation, and below the Puente or some other more recent formation. The sandstone facies carries the fauna of the *Turritella ocoyana* zone (as described by J. P. Smith, Journal of Geology, Vol. 18, pages 216 to 226, 1910) and any shales overlying this or its shale equivalent are to be considered as belonging to the Puente or some other more recent formation.

The Puente formation includes all shales and sandstones lithologically above the Monterey, or some other older formation, and below all later formations. The shales of the Puente formation are characterized by *Pecten pedroanus* Trask which ranges also into the Fernando formation, with which the Puente formation is closely allied. The sandstone of the Puente has so far yielded no fossils.

The fact that there may be one or more sandstone and shale facies in the same formation should not be lost sight of.

In this revised classification, the lower Puente shale and sandstone of Eldridge and Arnold (U. S. Geological Survey, Bulletin 309, Plates X and XVIII) are mapped as the shale and sandstone facies of the Monterey formation, while their upper Puente shale and sandstone are mapped as the shale and sandstone facies of the Puente formation. In Plate I of that bulletin the upper Sespe and Vaqueros are mapped as the sandstone and shale facies of the Vaqueros formation; the Modelo sandstone No. 1, and its overlying shale are mapped as the sandstone and shale facies of the Monterey formation; while the Modelo sandstone No. 2 and its overlying shale are mapped as the sandstone and shale facies of the Puente formation.

The Vaqueros, Monterey, and Puente formations are of great importance in the production of oil. Their shales are thought to be important sources of oil while their sandstones provide excellent reservoirs.

Fernando Formation.

The Fernando formation has been mentioned before as being closely allied to the Puente formation. As a rule, however, the Fernando exhibits a marked unconformity with the Puente, and its coarse, granitic, basal conglomerates and abundance, usually, of fossils make it readily distinguishable in the field.

In the region under consideration the Fernando consists of conglomerates, sandstone, sandy shale and clay, varying in thickness and sequence in the different parts of the region. South of Sulphur Mountain, northwest of Santa Paula, thicknesses as great as 14,000 feet are reported. This enormous thickness is probably due to overlapping beds due to the receding nature of the body of water in which the sediments were laid down.

The Fernando covers practically all of the area to the north and east of Saugus where it obscures the underlying formations and their structure. To the west, where the formations are more intensely folded, much of the Fernando has been eroded away, leaving the Miocene and Eocene sediments exposed.

In places in the Santa Clara Valley, as in parts of the Puente Hills, the lower Fernando can not be positively distinguished from the upper Puente, nor the upper Fernando from the lower Pleistocene. This may be due to continuous sedimentation in those parts from the late Miocene through the Pliocene and into the Pleistocene. This view seems to be substantiated by the gradation of faunas and the percentage of living species among them.

The Fernando formation is an important oil bearer, in that it is often made up of coarse sandstones and conglomerates which serve as excellent reservoirs in which oil may accumulate.

Pleistocene.

The Pleistocene sediments of the area consist of terrace gravels and sands exposed along the sides of the Santa Clara River Valley. Whereever exposed the Pleistocene consists of loose gravel, sand and arenaceous clay which in places rests with marked unconformity on the Fernando. The Pleistocene is not known to carry any oil in this district.

Structural Features of Drilled Regions.

As in the Puente Hills oil fields, the prominent structural feature of the Ventura and northern Los Angeles oil region is folding and faulting. In this latter region, however, the major axis of structural disturbances has been along east-west lines. Secondary structural folds and faults in a general northwest-southeast direction complicate the structure so that the oil sands are not so continuous as are those found in the San Joaquin Valley oil fields.

VENTURA RIVER REGION.

It is said that one of the first wells drilled for oil in California was one quarter mile north of Casitas in the Ventura River Valley. This was drilled into Monterey shale and at present flows sulphur water. Oil seeps from the shales just above the well. About two miles S. 70° W. of this prospect is the California Counties well, located on a sharply folded anticline in the Sespe formation. About one mile south of these wells a fault has brought the Fernando formation down into contact with the Sespe and Monterey formations. About one quarter mile south of this fault, on the west side of Ventura River, is the Traders' well. The Fernando covers practically all the country south of the fault and presents at least one major anticlinal fold which crosses Ventura River about one quarter mile north of Cañada de San Joaquin. Located on this anticline are the State Consolidated and Dabney wells, on the east and west sides of the Ventura River, respectively. None of the wells in this region have as yet been commercial producers of oil although small amounts have been reported.

WESTERN OJAI VALLEY AND MATILIJA REGIONS.

The region north of La Crosse in Santa Ana Valley and the western part of the Ojai Valley consists of Sespe and Vaqueros sediments covered by alluvium. Matilija Creek cuts through a series of hard buff and brown sandstones and shales of Tejon age. In the upper part of the creek these sediments are sharply folded along a northeast-southwest axis and are badly metamorphosed. About three miles northwest of Matilija heavy bedded conglomerates with interbedded sandstone and brown shale are exposed. These sediments are intensely folded and faulted, giving rise to numerous sulphur springs. The rocks of this region are so badly folded, faulted, and metamorphosed that it is extremely unlikely that they contain oil of economic importance. Holes drilled in the upper part of this formation, between Chismahoo Mountain and Coyote Creek, about seven miles west of Ojai, off the area mapped, were dry holes at depths ranging to 2,000 feet.

OJAI VALLEY REGION.

One and one half miles south of Nordhoff the Pirie wells are drilled into the Sespe red beds. The deepest of these was 950 feet, but only traces of oil and gas were encountered. A few prospects were drilled in Lion Canyon, two miles to the east of the Pirie wells, where a small amount of heavy oil was produced for a short time from a 1,300-foot well in the Monterey formation.

The eastern end of the Ojai Valley presents the structure of a broad syncline, the south side of which has been faulted in an east-west direction, which accounts for the rather abrupt northern flank of Sulphur Mountain. This fault marks the contact of the Sespe red beds and the Monterey shale and passes just south of the Silverthread, or Sisar, wells which lie north of Sisar Creek in Sections 17 and 18, T. 4 N., R. 21 W. From there it passes eastward to Sespe Creek, marking the contact of the Tejon with the Monterey and Fernando formation.

A group of wells located along the divide between the upper Ojai Valley and Sisar Canyon are producing a small quantity of heavy oil. Some of the oil is obtained from sandstone while some is reported as being obtained in a broken shale formation. Minor folding and faulting is common throughout the region.

SISAR CREEK REGION.

A number of wells have been drilled into a narrow strip of steeply tilted Sespe formation exposed north of the Sisar Creek fault. The formations in this region are overturned and the oil has apparently accumulated in the Sespe formation from the underlying shales of the Monterey formation, its migration being aided by faulting. Seepages are common in the fractured shales south of Sisar Creek, but no wells drilled in that region have yielded oil in sufficient quantity to be of much economic importance.

Most of the oil in this region is obtained from wells ranging in depths between 400 and 800 feet, although a few producers are as shallow as 150 feet, and as deep as 2,800 feet. The sands below 800 feet have in most cases increased the productiveness of the wells but little. The gravity of the oil ranges from 19° to 28° Baumé.

REGION SOUTH OF SULPHUR MOUNTAIN AND SANTA PAULA RIDGE.

The territory on the south flank of Sulphur Mountain is producing some oil. The wells are located close to the fault contact of the Monterey shale and Fernando formation near the heads of Aliso, Wheeler, Salt Marsh, and Adams canyons. Most of the oil is obtained from depths less than 500 feet but some prospects are reported as deep as 2,000 feet. Oil seepages are common along the fault and the early method of obtaining oil was by tunneling. Small amounts of oil will probably be taken from this region for a long time, but the territory is not favorable for the location of wells from which large production is expected.

South of the fault, south of Santa Paula Ridge, some light oil is obtained from the Monterey and Fernando formations. The wells range in depth from 1,000 to 1,500 feet but are not large producers. Considerable oil may yet be obtained from this region, but wells of large continuous production are not to be expected.

SESPE AND HOPPER CANYON REGIONS.

In the region of Sespe Creek the geologic formations are much disturbed by faulting. The headwaters of the creek follow an east-west fault, while the lower portion, known as Big Sespe Canyon, follows a north-south fault. The geologic map (Plate III) shows only the lower portion of the creek. The east-west fault has brought the northerly dipping Sespe red beds on the north side into contact with the southerly dipping Tejon and overlying Sespe red beds on the south side of the fault. East of Big Sespe Canyon the Sespe, Vaqueros, Monterey, Puente, and Fernando formations are folded along a northwest-southeast axis which plunges southeastward. So intensely are these rocks folded that they are faulted and overturned, and nowhere present structure favorable to the accumulation of very large amounts of petroleum, although some anticlines and synclines have been moderately productive.

A few wells drilled, in Sec. 23, 5–20 in the northern part of Big Sespe Canyon, to depths ranging from 300 to 2,000 feet, have produced only small quantities of heavy oil. The oil is thought to be obtained from the upper Tejon formation. The same strata are tapped by wells near Devilsgate on the Coldwater anticline where some heavy oil has been produced. The region does not look very promising, geologically, for productive prospecting.

Considerable development has been carried on in Sespe Canyon in Sec. 1, 4–20, north of the mouth of Little Sespe Creek. The wells have been drilled into the Sespe formation on the flanks of a continuation of the Oat Mountain syncline to depths ranging from 600 to 1,500 feet. The oil is obtained from several horizons and averages about 28° gravity, but has not been found in very great quantity. The sharply folded structure is apparently not conducive to long-lived wells, as development has shown.

The wells on Little Sespe Creek near the center of Sec. 6, 4 N. 19 W., range in depth from 800 to 1,600 feet, where oil is taken from the upper part of the Sespe formation. Groups of wells follow the outcrop of the lower Vaqueros formation in a northeast direction as far as Sec. 5, 5 N. 19 W. These wells are mostly located on or near anticlines and derive their oil from the upper part of the Sespe red beds, or from the lower Vaqueros formation. The wells near the head of Fourfork Creek, in Sec. 32, 5 N. 19 W., range in depth from 1,200 to 1,800 feet while the gravity of the oil is about 32° Baumé. The wells near the head of Tar Creek in Sec. 28, 5 N. 19 W., range in depth from 230 1,700 feet while the gravity of the oil is about the same as that from the Fourfork wells. The production of the wells falls off rapidly after the first few months.

East of the Sespe and Fourfork creeks the geologic formations are folded along northwest-southeast axes which, with a few exceptions, turn to an east-west direction east of Hopper Canyon. The Vaqueros and Monterey are the important oil formations in this region. Most of the drilling has been done in the canyons where they cut across likely anticlines.

Probably the most favorable drilling territory in this vicinity is along the north flank of the Nigger Canyon anticline and along the Hopper Canyon anticline. There are exposures of oil sand in the Vaqueros formation on the west face of Oat Mountain, and also in the Monterey formation from the mouth of Pole Canyon to Fairview Canyon.

The principal oil zones are those of the Monterey (lower Modelo) formation consisting of shallow sands interbedded in the Monterey shale and those of the Vaqueros sandstone interbedded in the Vaqueros shale. The oil zones of the Monterey range to 1,000 feet below the surface, while those of the Vaqueros range usually from 1,500 to 2,000 feet.

The maximum initial production per day for some of the older wells of the Sunset, Modelo, and Harris Oil Company was 75 barrels. Wells as a rule drop off rapidly for the first few months and then maintain a more steady production for many years at rates of from 5 to 25 barrels. The oil varies from 14° Baumé in the shallower Sunset and Harris wells to over 30° Baumé in some of the Modelo wells. The deepest Harris well obtained the lightest oil and the largest production of the group. In the long run wells over 2,500 feet deep are said to be no more profitable than shallower ones.

On account of the intricate structural conditions water problems are likely to be confined to small local areas, thus the effect of uncontrolled water in a well is not widespread, nor does the experience in one locality give much information about what may be expected in another locality not on the same structural feature. There is no way of foretelling the amounts, depths, nor quality of water on untested structure in this district. It is self-evident that an anticline will be freer from water and more favorable than a syncline. The shales are badly fractured and the ''shells'' short so there is no good natural stratum in which to shut off the water, although some of the clays are suitable in which to land the casing.

A few wells have been drilled as far east as San Martinez Chiquito Canyon and Castaic Valley. These wells started in the Fernando formation and drilled to depths ranging from 500 to 2,500 feet. Traces of oil and asphalt are reported from some of these wells. Probably if oil in paying quantities is struck in this region it will be deep because of the eastward plunging of the geologic structural axes.

NEWHALL REGION.

The Newhall Region includes the oil wells in the vicinity of Elsmere, Placerita, Wiley, and Pico canyons.

The Elsmere wells are located in the three branches of the upper part of Newhall Creek, in Secs. 6, 7 and 8 of T. 3 N., R. 16 W. They are drilled into the lower Fernando, or through the Fernando into the underlying Vaqueros formation, from which some heavy oil is obtained. Granite is exposed one mile east of the region and has even produced some light oil near the Fernando-Granite contact in Placerita Canyon. The oil produced in this territory has all come from a depth of less than 1,000 feet. The wells have been small producers and are nearly all abandoned at the present time.

A few wells drilled east of the area mapped, in Pacoima and Tejunga canyons in T. 3 N., R. 14 W. and T. 3 N., R. 13 W. encountered only small seepages of oil.

The wells of Pico and Wiley canyons, together with those of De Witt, Towsley, Rice, and East canyons, have nearly all been drilled along anticlines in the Vaqueros formation. The wells vary in depth from 500 to 2,500 feet because of the highly folded, and sometimes overturned, nature of the strata. The gravity of the oil varies in the different localities from 20° to 40° Baumé.

All the wells have been steady but small producers, and the conditions are similar to those in the region east of Sespe Canyon north of the Santa Clara River.

TAPO, EUREKA AND TORREY WELLS.

The Tapo, Eureka and Torrey wells are in the canyons known by those names south of Camulos. All are located along anticlines in the Vaqueros formation and the oil is obtained from sands interbedded in the organic shales.

The Tapo wells range in depth from 300 to 2,000 feet, while the oil is reported to range between 20° and 24° Baumé in gravity. Only a few wells were drilled in this region and none were very good producers. Most of them are now abandoned.

The Eureka wells range in depth from 180 to 1,900 feet, while the oil has a gravity of about 24° Baumé. Most of the wells are located on the north side of an anticline in the Vaqueros formation and are small producers at the present time.

The Torrey wells range in depth from 700 to 2,500 feet, while the gravity of the oil is reported to be about 30° Baumé. Most of the wells are operated by the Union Oil Company and are producing some oil.

BARDSDALE, SHIELDS, GUIBERSON AND WILEY WELLS.

The wells south of Bardsdale, and those in the Shields, Guiberson, and Wiley canyons, are located along an anticline in the lower Vaqueros and Sespe formations. The oil is derived from the sandstones which are interbedded with the shales.

The Bardsdale wells are most all on the north flank of the anticline and are drilled to depths ranging from 425 to 2,000 feet. Considerable oil averaging about 25° Baumé has been produced. Several of the wells are still producing some oil.

In Shields canyon considerable development has been carried on during the last year by the Montebello Oil Company, the principal operator in Ventura County. Drilling has been carried eastward towards the Calumet Oil Company's lease. It is reported that about 1,000 barrels of oil per day are produced, while considerable gas is being converted into gasoline by a recently installed compressor plant.

The wells drilled in Guiberson Canyon to depths of 1,200 and 1,600 feet have not been productive.

Wells in Wiley Canyon were drilled to depths ranging between 600 and 1,600 feet. They produced considerable oil at first but are only pumped occasionally at present.

WELLS OF THE SIMI VALLEY REGION.

Well No. 1 of the Scarab Oil Company in Sec. 32, 3–18 was drilled in 1910 to a depth of about 2,700 feet. The production was recently reported as considerably less than thirty barrels per day of about 17° gravity oil. Considerable water is pumped with the oil. The well is located on northwesterly dipping strata of the Vaqueros formation.

The Union Oil Company's well in the northwest quarter of Sec. 33, 3–18 is about 1,000 feet deep and is said to have produced about 50 barrels of 17° gravity oil per day.

The Petrol Company has nine wells near the mouth of Tapo Canyon, two miles northwest of Santa Susana. The wells range in depth from 600 to 1,800 feet and produce an oil of 30° to 35° gravity. Two oil zones appear to be present. The first of these is about 2,000 feet below the top of the Vaqueros formation. It is about 1,000 feet thick and is probably the same zone as is found at Bardsdale and in Sespe Canyon. The second zone is in the Tejon sand and shale about 600 feet stratigraphically below the top of the formation.

The Santa Susana Syndicate has five producing wells east of Tapo Canyon. No. 1 (West) was finished with 12½-inch casing and struck five feet of oil sand at 708 feet. No. 2 (West) is 1,935 feet deep, and appears to be on a break in the formation, as the oil is not produced directly from the oil sand. No. 3 (West) was drilled to a depth of 795 feet with 10-inch casing. The main oil sand, about twenty feet thick, was struck at a depth of 775 feet. No. 4 (West) is 929 feet deep with 8¼-inch casing. Oil sands were struck at 550, 930 and at 1,035 feet. No. 1 (Middle) is 1,083 feet deep with 6⅝-inch casing. These five wells produce about 300 barrels of about 30° gravity oil per day.

The Calabasas Oil Company is drilling a well into the Tejon formation three miles southwest of Santa Susana in Sec. 22, T. 2 N., R. 18 W. The well is now 1,900 feet deep. Considerable gas has been encountered in the last 200 feet.

SCATTERING WELLS.

The Placerita Oil Company is drilling a well in the northwest quarter of the southwest quarter of Sec. 30, T. 3 N., R. 16 W., at an elevation of 875 feet. The well was 865 feet deep with 6⅝-inch casing in May, 1914. An artesian flow of water was struck at 820 feet. Considerable difficulty has been encountered in drilling because of ''boulders.'' No trace of oil has yet been struck. The well is drilled on the south side of a minor overturned and eroded anticline in the Fernando formation. A fault to the north has brought the Fernando down into contact with the Monterey formation. The general structure to the south of the well is that of a broad syncline pitching to the southeast. Tar seepages are reported along the fault to the north.

A well was recently drilled by A. J. Stowe at the head of Aliso Canyon in Sec. 27, T. 3 N., R. 16 W., in the Monterey formation. A shallow well in Bull Canyon in Sec. 36, 3–16 was abandoned as no oil was encountered.

The Marine Street Investment Company is drilling a well about one mile north of Moorpark in Sec. 33, T. 3 N., R. 19 W. When visited in May, 1914, it was 1,324 feet deep with 6⅝-inch casing. The well started in soft buff colored Fernando sandstone and no water, tar, or oil has so far been encountered.

The Camarillo Oil Company has twenty-two shallow wells north of Conejo Mountain, three miles S. 70° E. of the town of Camarillo. The wells are pumped occasionally and oil of low gravity is obtained. The oil is all used locally on the roads and for fuel. The wells are drilled close to a seepage which apparently rises along a fault. Vaqueros sandstone, dipping to the north, is exposed to the south and east, while basalt and alluvium cover all strata to the north.

CONCLUSION.

The value of geological investigation, preliminary to prospecting for oil in Ventura and northern Los Angeles counties, can not be too strongly impressed upon all operators. Anticlines and faults have been the two great factors in oil accumulation throughout the region. (See Plate III.) Oil has thus far been found in all the formations from the Tejon to the Fernando, inclusive, and it is not impossible that even lower formations may yield some oil in the future.

Considerable of the region remains to be prospected in a thorough manner and probably many small areas yet remain which will yield their quota of oil.

It should be borne in mind that no wells in the whole region have been large producers. The production falls off rapidly for the first few months, after which a more steady production may continue for several years. The oil from the Tejon formation is usually light, averaging about 32° Baumé, while the oil from the Miocene formations ranges in gravity from 12° to 40° Baumé. Deep wells are usually no more profitable in the long run than shallow ones. Water troubles are common and in sharply folded or fractured regions it sometimes can not be successfully shut off. Because of the intricate structural conditions water problems are likely to be confined to small local areas. The effect of uncontrolled water in a well is not widespread and the experience in one locality can not be depended upon for the conditions to be expected in another locality with different structural features. There is no way of foretelling the amounts, depths nor quality of water on untested structure in any part of the region.

Thus far development has shown the possibilities of a comparatively small portion of the territory. Future "wildcat" holes may develop considerable territory which at present can be only pointed out as possible by the geologist.

CHAPTER IX.

SANTA BARBARA COUNTY.

History of Oil Developments.

The first large attempt to utilize any of the well known oil or "maltha" seepages in California, seems to have been at Carpinteria. In 1857 Mr. Charles Moirell, a San Francisco druggist, "erected quite extensive works, well equipped with cast iron retorts, etc., in which the crude material was refined by distillation, and oil produced; but for some reason not now known, the enterprise was a failure.[1]

About 1877 the first well was drilled at Summerland and oil found, but the well was abandoned. In 1887 Mr. H. L. Williams drilled a well and encountered heavy oil. In 1890 a shallow well encountered considerable gas. In 1895 there were nine operators with twenty-eight wells which produced 16,904 barrels, or an average of a little less than two barrels per well day. In 1900 there were twenty-two operators, 305 producing wells, 59 abandoned wells. The production for the previous year was 208,000 barrels, or an average of a little over two barrels per well day, although W. L. Watts' report[2] also states that five barrels was the average. Wells were from 150 to 300 feet deep, costing about $1 per foot, aside from casing. Price of oil was 90 cents and production cost 25 cents to 35 cents per barrel.

Development continued until some time previous to 1903, when there were 198 producing wells and 214 idle or abandoned.[3] In 1906 the number of producers had fallen to 189.[4] At the present time (1914) there are 125 wells listed as producers, but there is little or no activity in the field, some oil going to Santa Barbara for fuel and some being locally refined to asphalt. In preparing this publication only the most hurried examination was made of the Summerland field.

The Santa Maria field (see Plate XV), and the surrounding country, were long known to contain seepages of oil or brea. Prospecting commenced as early as the year 1900, near Casmalia, Careaga and Santa Ynez.[5] In 1901 and 1902 the Western Union and Pinal companies finished producing wells.[6] December, 1903, saw twenty-one producing and ten abandoned wells.[7]

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[1] Henry DeGroot, Fourth Annual Report of the State Mineralogist, 1884, p. 294.

[2] Bulletin 19, California State Mining Bureau, p. 103.

[3] Bulletin 32, California State Mining Bureau, p. 32.

[4] U. S. Geol. Surv., Bulletin 321, p. 17.

[5] Bulletin 19, California State Mining Bureau, p. 104.

[6] U. S. Geol. Surv., Bulletin 322, p. 14.

[7] Bulletin 32, California State Mining Bureau, p. 47.

The diagram of these fields (Figs. 72 and 73) showing rate of development and production are from figures furnished by the Standard Oil Company. The table of annual production and price for Santa Barbara County (page 412) is from the State Mining Bureau records.

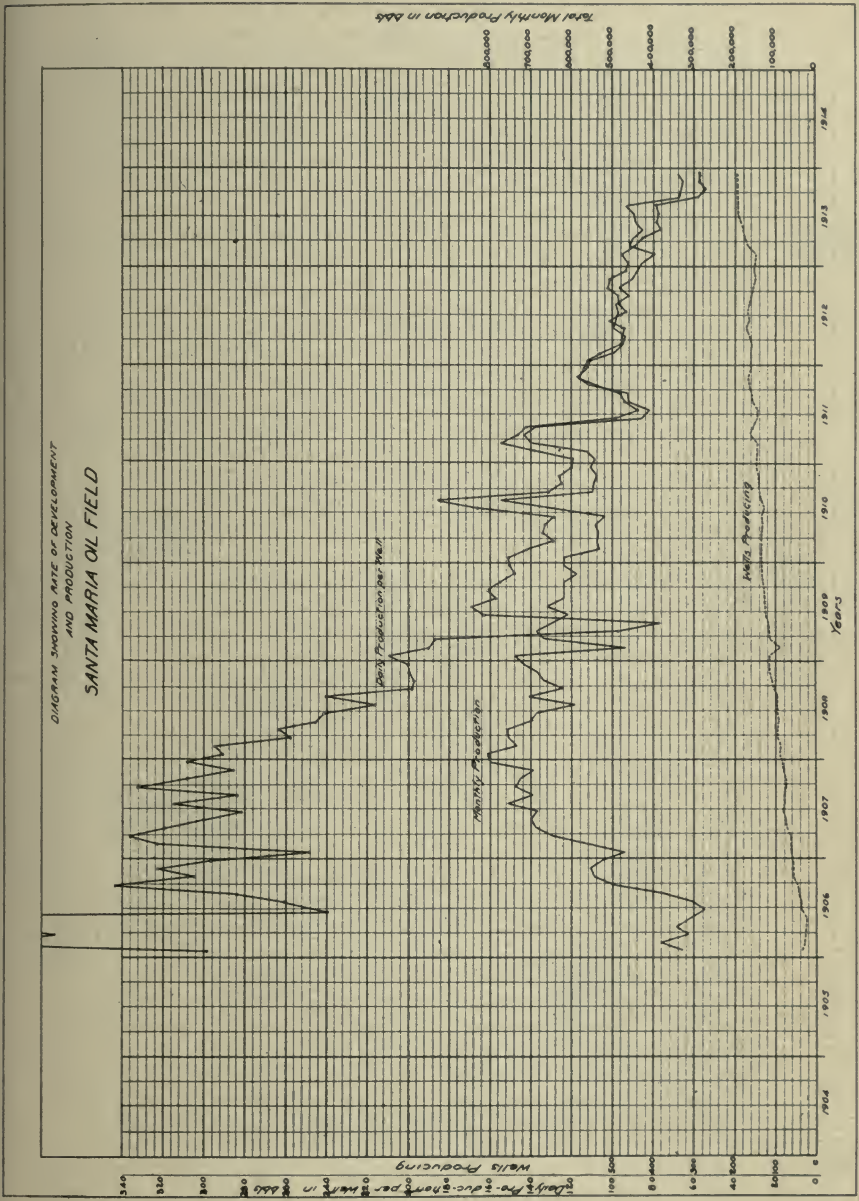


Fig. 72.

Santa Maria developments began in 1901, and the number of wells and production increased until 1906, where the Standard Oil records and our diagram begin. Early in 1906 monthly production was about

300,000 barrels and rose to a maximum of 800,000 barrels at the end of 1907. Since then it has declined to about 350,000 barrels. Development has regularly gone forward at the average rate of 19 new wells

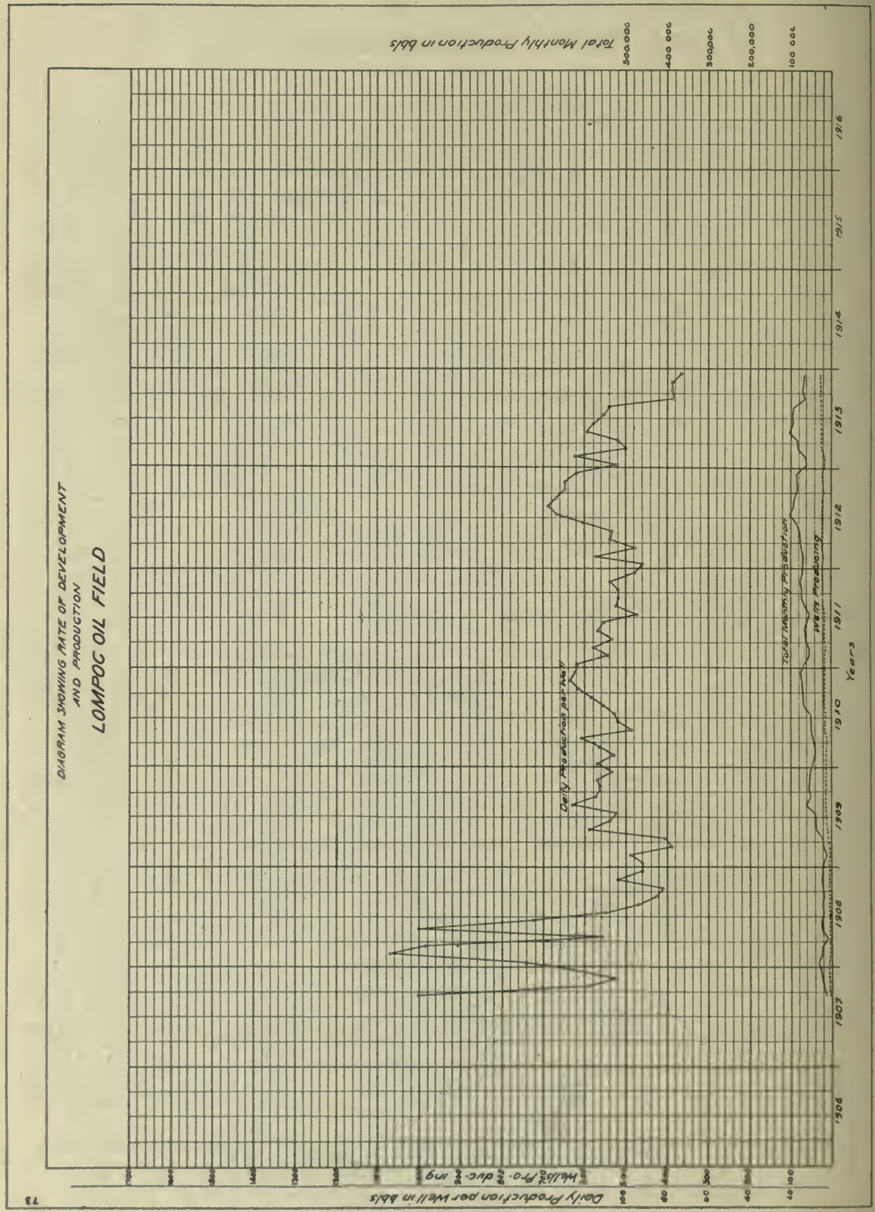


Fig. 73.

per year until the end of 1913, when there were 194 producing wells. The decline in production per well has been more rapid than in any other California field; during 1906 and 1907 the rate was about 300 barrels per well per day and fell to only 160 barrels early in 1909; since then it has been irregular and less rapid, standing at less than 60 barrels at the end of 1913. Most of the production now comes from the western region, or "old" field. The peculiar nature of the deposits, in shale, and the fact that recently deepened wells have greatly increased their production, makes prediction of future production very difficult if not impossible, from the diagram alone.

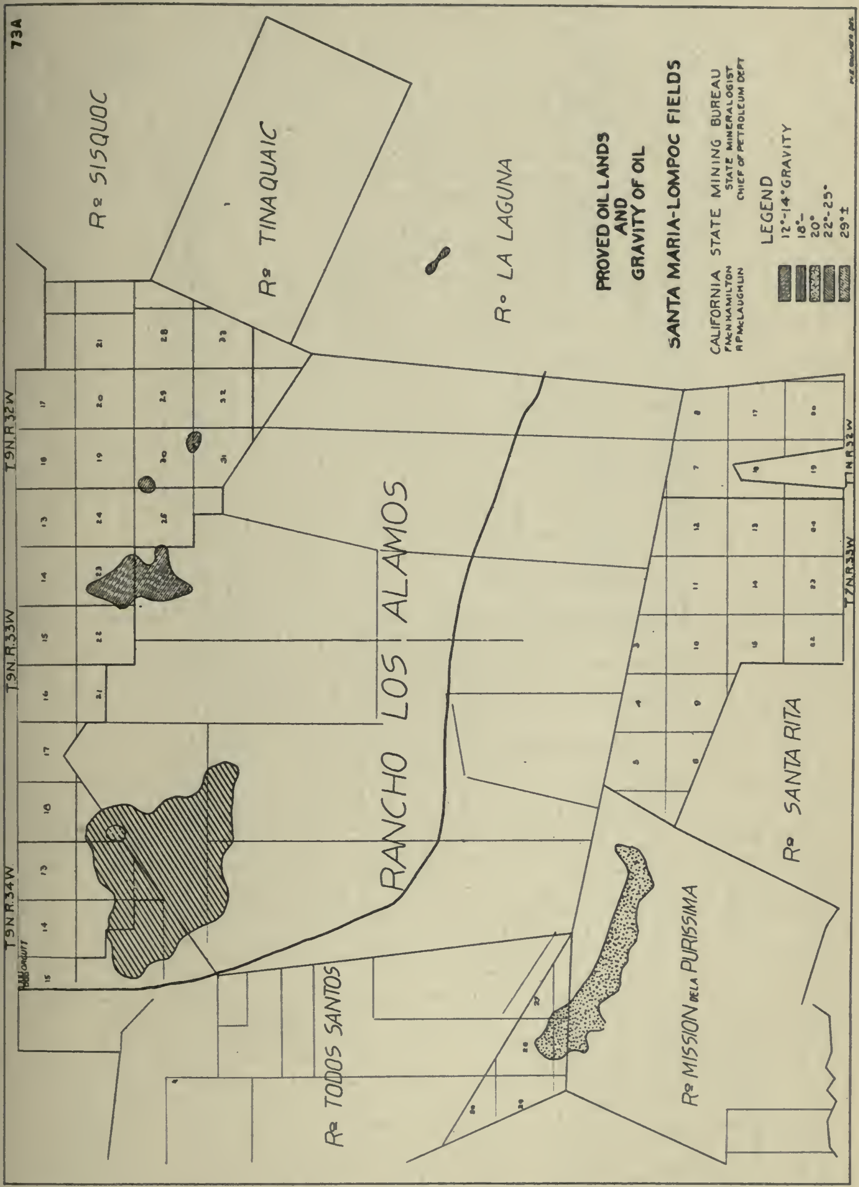

73A
R° SISQUOC
R° TINAQUAIC
R° LA LAGUNA
PROVED OIL LANDS AND GRAVITY OF OIL
SANTA MARIA-LOMPOC FIELDS
CALIFORNIA STATE MINING BUREAU
F. McN. HAMILTON STATE MINERALOGIST
R. P. McLAUGHLIN CHIEF OF PETROLEUM DEPT
LEGEND
12°-14° GRAVITY
18°
20°
22°-25°
29°±
T9N R32W
T9N R33W
T9N R34W
RANCHO LOS ALAMOS
T7N R33W
T?N R32W
R° SANTA RITA
R° MISSION DE LA PURISSIMA
R° TODOS SANTOS

Fig. 73A. Proved oil land and gravity of oil. Santa Maria Field.

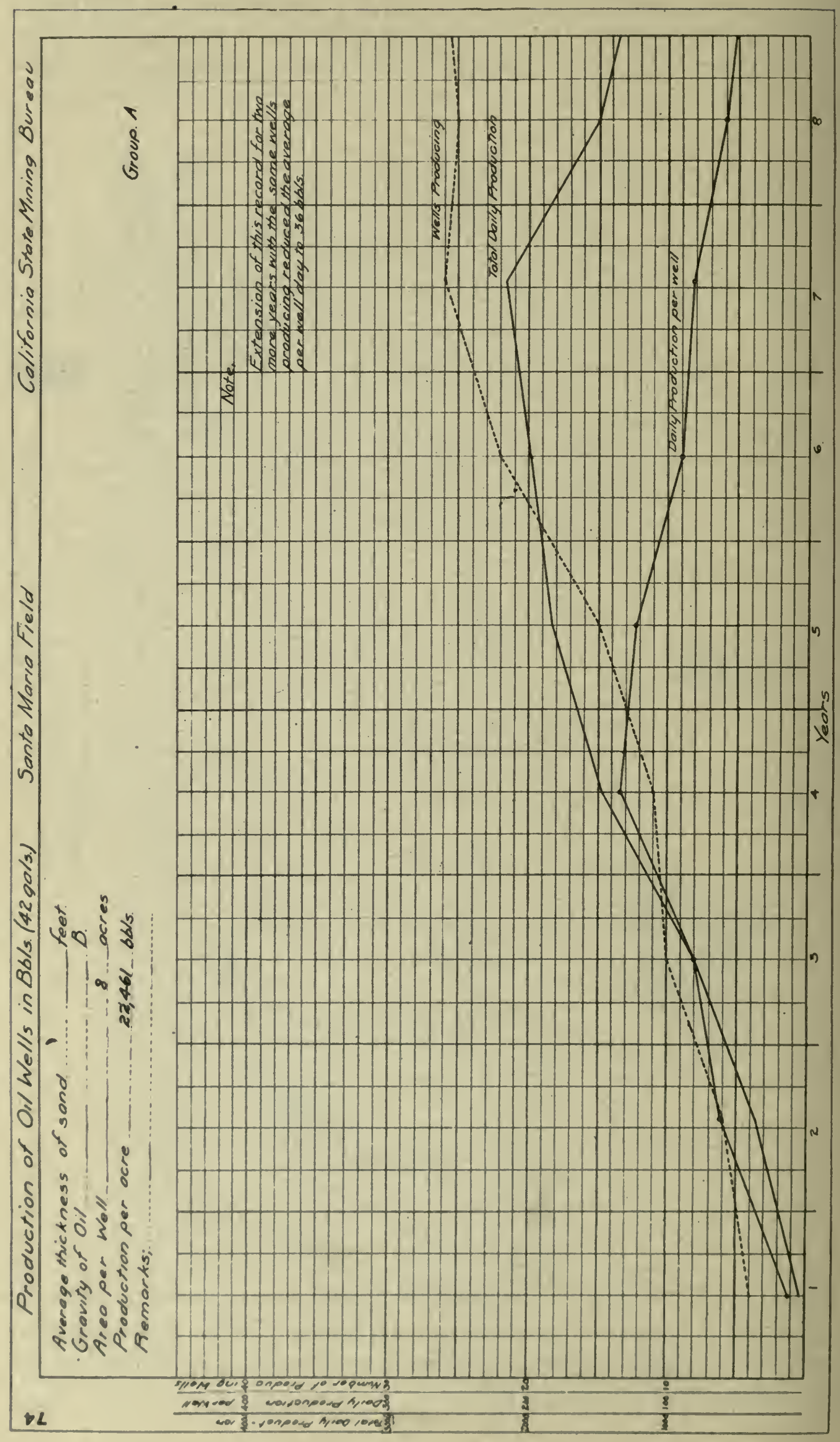


Fig. 74. Production record of 26 wells.

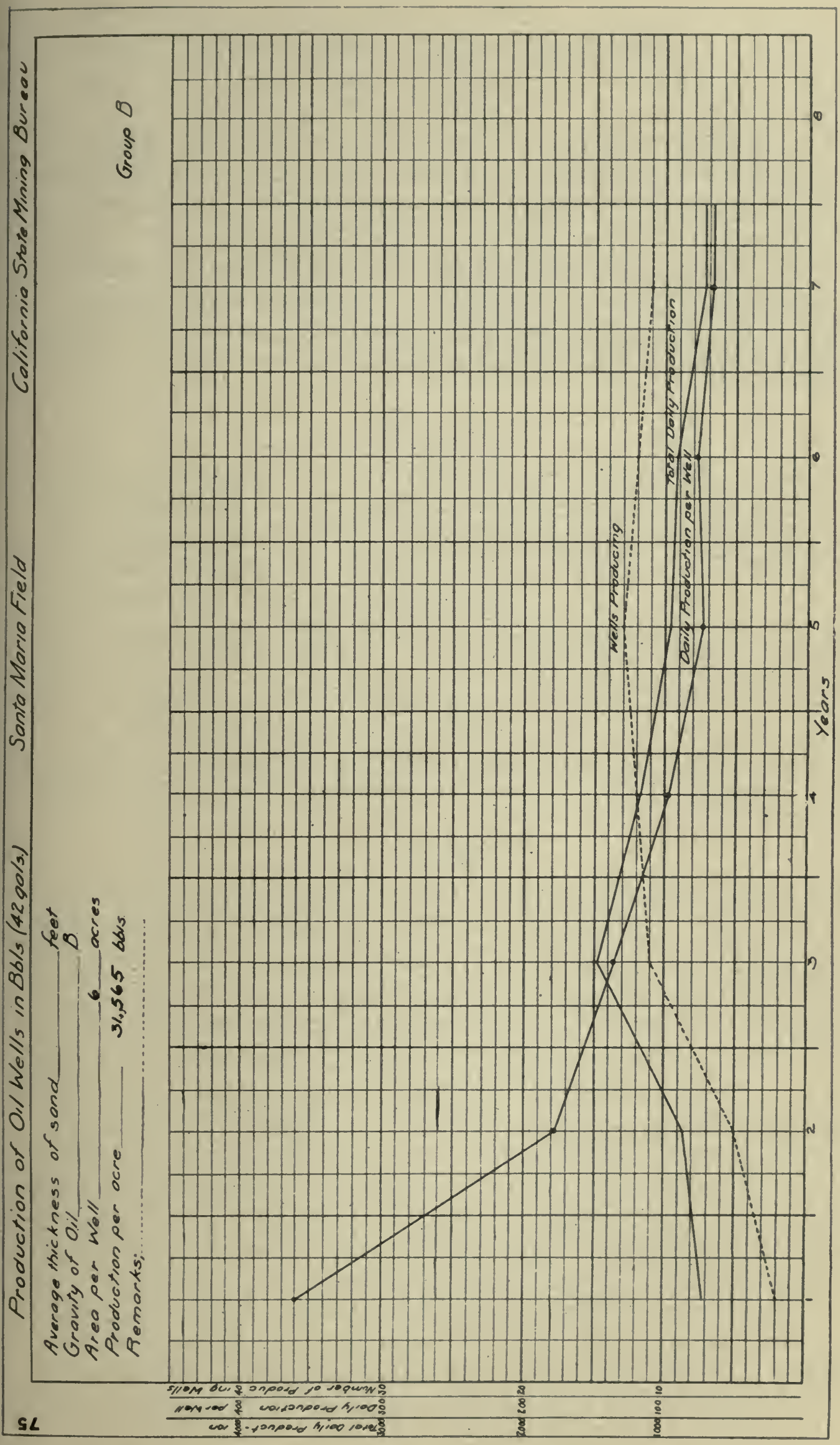


Fig. 75. Production record of 13 wells.

Lompoc developments, as shown by the diagram, began in 1906 and were carried on with some irregularity until the end of 1913, when there were 30 producing wells, and monthly output has steadily mounted to about 100,000 barrels. The rate of production per well varied from 200 to 100 barrels per day for the first year of the field and has since remained between 100 and 80. Nothing definite can be said as to decline and the wells are so far apart that the field may be considered to be in its infancy so far as the present proved area is concerned.

Life of wells in the Santa Maria Field is a subject upon which considerably more data are needed than we have been able to collect. The two accompanying diagrams (Figs. 74 and 75) lack the detail similarly shown for groups of wells in other fields.

GEOLOGY OF THE SANTA MARIA OIL REGION.

Location.

The Santa Maria oil region, Santa Barbara County, lies between the Santa Ynez Mountains on the south and the San Rafael Mountains on the northeast. The territory is included by townships 6 to 10 north and ranges 30 to 35 west, inclusive. It embraces the Santa Maria oil field in Secs. 22, 23, 24, 25, 26, 27, 35 and 36 in T. 9 N., R. 34 W., and Secs. 19 and 30, T. 9 N., R. 33 W., and Secs. 5 and 6, T. 8 N., R. 33 W.; the Cat Canyon field in Secs. 23 and 26, T. 9 N., R. 32 W.; and the Lompoc field in Secs. 28, 33 and 34, T. 8 N., R. 34 W. and Secs. 1 and 2, T. 7 N., R. 34 W.

Topography.

The topography of the Santa Maria region is governed by the mountain ranges which have a northwest-southeast trend. The Monterey formation flanks the San Rafael Mountains to an elevation of 3,125 feet in Manzanita Mountains, while it reaches an elevation of 1,500 feet in the Lompoc Hills of the Santa Ynez range.

The intermediate range, formed by the Casmalia and Los Alamos Hills, attains an elevation of 1,624 feet in Mount Lospe and 1,338 feet in Mount Solomon. This range separates the Santa Maria Valley from the San Antonio and Los Alamos valleys.

The oil wells so far drilled have been at moderate elevations, which has enabled the operators to make use of a gravity system of pipe lines.

Geology.

The surface geology of the region has been thoroughly mapped by Ralph Arnold and Robert Anderson (U. S. Geol. Survey, Bulletins 317 and 322). The formations represented consist of rocks of the Vaqueros and Monterey formations overlying unconformably the Franciscan and Cretaceous-Eocene series. The Monterey series in much of the region is overlain unconformably by sediments of the Fernando formation and by dune sand and alluvium of Pleistocene and Recent age.

The important formations, with reference to oil, are the Monterey and Fernando. The accompanying cross-section, Fig. 76, shows the relation of the two formations in the old portion of the field where the oil is found only in the Monterey. In the Cat Canyon field the overlying Fernando is productive. In the Lompoc field the Monterey contains the oil. The oil in the Monterey may in places be in true bedded sands but at other points it is undoubtedly in fracture zones.

The cross-sectional drawing illustrates the fact that operators are not sufficiently alive to the great value of underground drawings. It will be noted that not all of the sands have been entered by some wells.

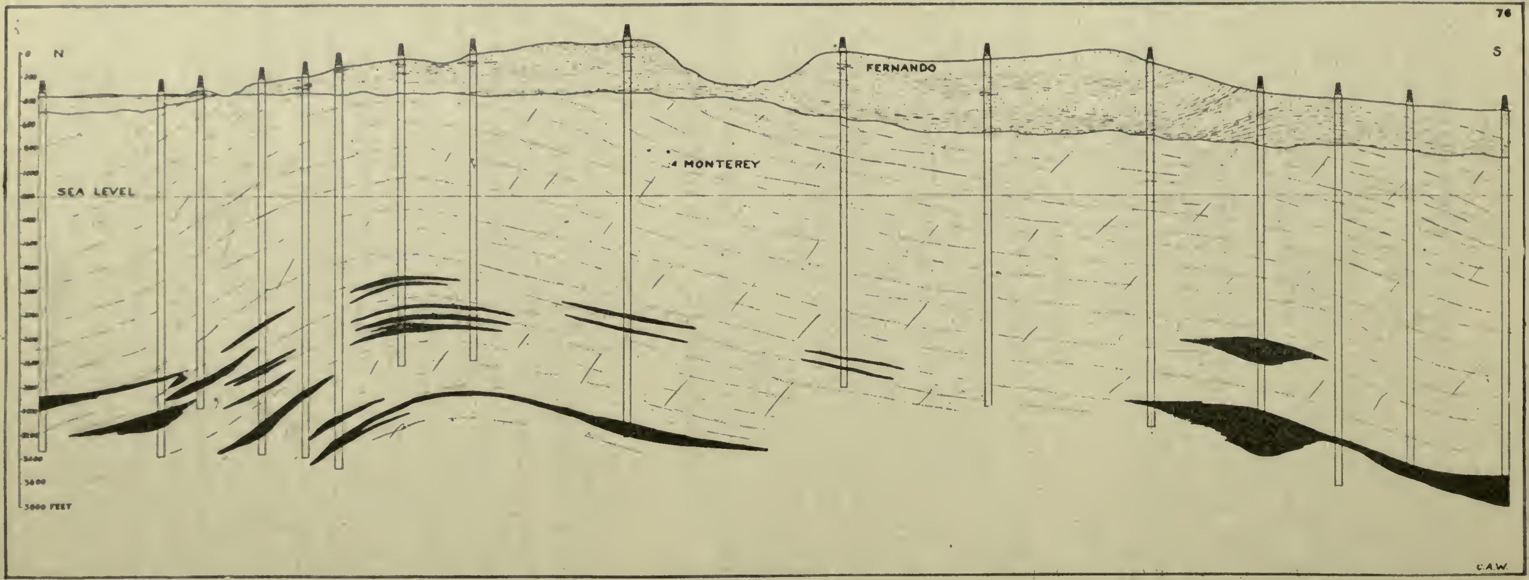


Fig. 76. Geologic cross section in Santa Maria Field.

As the Fernando formation covers a great deal of the Monterey, and as the two are not necessarily bedded parallel to each other, it will be seen that predictions, based upon surface observations, are more difficult than in some other fields.

Contrary to ordinary belief, and previously published reports, water troubles in this field are quite serious. Thorough investigation by the operators will be a profitable investment.

The oil horizon in the old part of the Santa Maria field varies from 2,000 to 3,500 feet below the surface. The gravity of the oil ranges between 20° and 35° Baumé.

In places the Fernando formation has acted as a reservoir for oil accumulation. In the Cat Canyon field, in Secs. 22, 23 and 26, T. 9 N., R. 33 W., the oil is obtained from the Fernando, while in the old part of the Santa Maria field the oil is manifest in the Fernando by large brea deposits near the surface, but the sands are unproductive. The oil sands in the Cat Canyon field lie at a depth ranging from 2,500 to 3,200 feet. The oil is heavy, ranging between 11° and 16° Baumé.

Summary.

The following remarks as to future development are based on what is known of the structure of the region, together with the results of "wild-cat" wells.

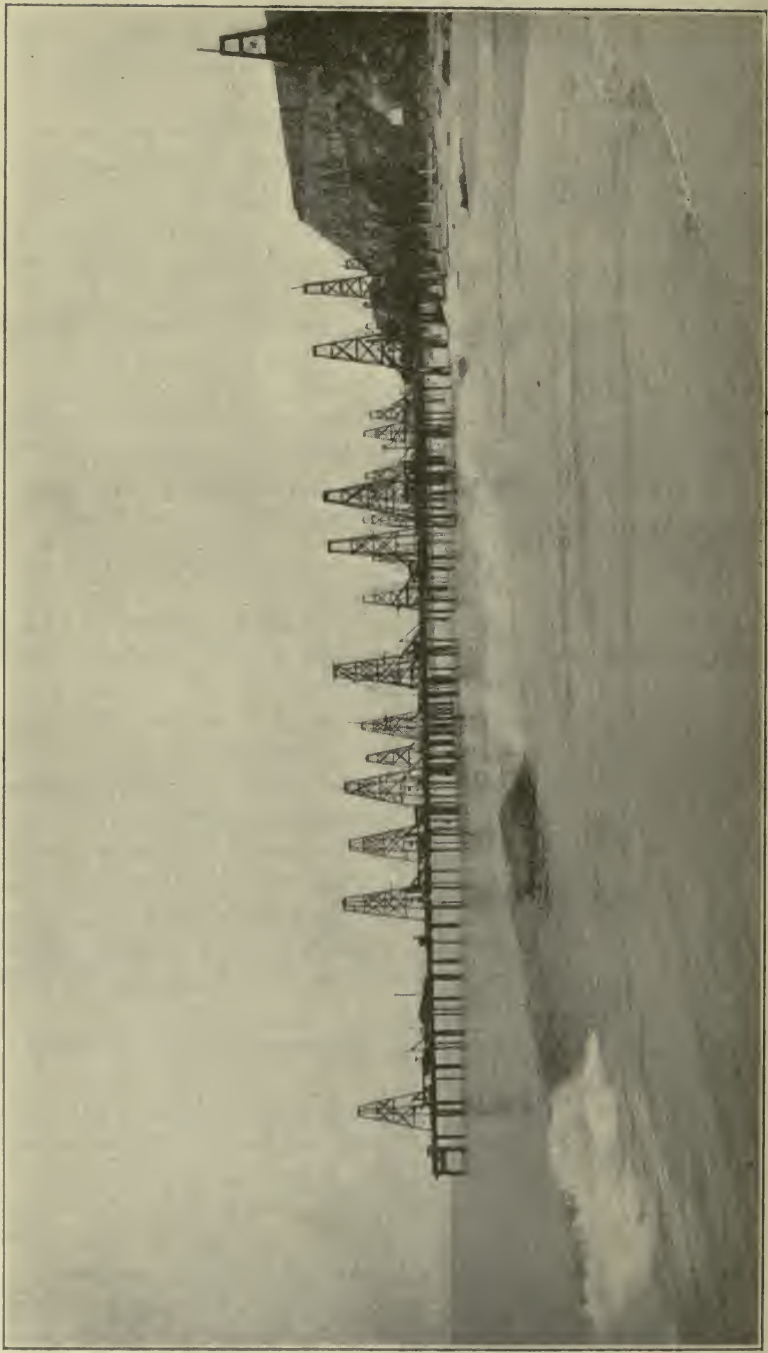
The oil is taken from the Monterey formation in the Santa Maria and Lompoc fields. Anticlinal structure in the Monterey is favorable, but the presence of overlying Fernando is not necessary to the accumulation of oil in these fields. Taking these facts into consideration there is a large amount of territory in which the presence of light oil is possible, but it can only be proved by drilling. New wells have developed some oil in places along the anticline in the Los Alamos Hills, but drilling along the anticline in the Purissima Hills east of the Lompoc field has so far been largely unsuccessful. Wildcat wells in the Santa Rita Hills have added no new producing territory.

In the region of Casmalia the oil encountered has been too heavy to pump economically.

Wells drilled west of Tepusquet Creek on the southwest flank of the San Rafael Mountains, have yielded no oil and the region is not promising because of its proximity to igneous and Franciscan rocks.

The oil of Cat Canyon is taken from the sands of the Fernando formation. The territory so far developed is small and the oil is heavy. Doubtless the field can be considerably enlarged by further drilling.

Although considerable surrounding territory is covered with the Fernando formation and several test wells have been put down, the oil encountered has, in most cases, been heavy and difficult to pump.



Summerland Oil Field in Santa Barbara County. Photograph by R. B. Moran.

Considerable oil may reasonably be expected to be taken from moderately folded anticlines in the Monterey formation; and in such Fernando, overlying steeply folded and fractured Monterey, as furnishes sufficient clay or shale capping.

The following list of outlying wells will indicate the possibilities that remain to be tested. It is believed that the figures are fairly accurate, but of course exact records were in some cases not available. As the land here is not generally surveyed into sections, locations of wells must be found by consulting our map in the accompanying folio. In a general way the list begins near Casmalia and circles to the right around the proved fields:

Traders' Union, drilled 1903	3,350	feet; some tar at 2,900 feet; water never shut off; casing pulled.
Casmalia Rancho O. and D. Co. No. 1	1,700	feet, asphalt.
Pacific Oil Transportation, 1904	2,465	feet, considerable tar.
National No. 1, 1905	3,825	feet, 20° B., oil and deep water.
Recruit	3,300	feet, water at 3.250 feet, 4 barrels, 19° B.
Newhall	3,900	feet, show at 2,400 feet, sulphur water at bottom.
Claremont	3,700	feet, all blue shale.
Casmalia	4,000	feet, all blue and brown.
West Huasna	3,900	feet, some oil 2,900 feet, 19°.
Graciosa No. 19	4,200	feet, no oil.
Graciosa No. 18	----	rig only.
Graciosa No. 20	4,000	feet, water.
Las Flores No. 3	3,400	feet.
Las Flores No. 1	----	25 barrels 16° at 2,600 feet.
Bell No. 3	3,900	feet, no oil.
Bell No. 2	2,900	feet, 60 barrels 20° B.
Recruit No. 1	3,565	feet, heavy oil at bottom.
Shaw No. 1	2,900	feet, little oil 16°; 2,000,000 feet gas.
Santa Maria Petroleum	----	150 barrels.
West and New Pennsylvania	3,500.	3,600 feet each, heavy oil.
Pinal F. No. 1	2,100	feet, water.
Pinal F. No. 2	4,200	feet, suspended; little oil.
Dispatch	3,200	feet, heavy oil.
Ideal No. 3	3,200	feet, water trouble.
Summit, Sec. 11	3,200	feet, little oil and water.
Merchants	3,100	feet, no oil.
Carpinteria	3,100	feet, salt water.
Gato Ridge	2,100	feet, suspended.
Dome (Tinaquac)	2,800	feet, sulphur.
Dome No. 1 W.	3,700	feet, 50 barrels.
Dome Toguay	----	Some oil.
Princess	3,200	feet, water, no oil.
Carranza	3,000	feet, no oil.
Oil Field Syndicate (Bell Ranch)	3,740	feet, at 2,950, 18° oil, 80 barrels.
Fox, Sec. 13	2,965	feet, no oil.
Purisima Hills No. 1	3,600	feet, no oil.
Purisima Hills No. 2	3,500	feet, suspended.
Lompoc O. and D. No. 1, Sec. 9	4,800	feet, no oil.
Lompoc O. and D. No. 2, Sec. 8	3,800	feet. heavy oil. water trouble.
Dome (Gem)	2,800	feet, abandoned, 20 barrels.
Federal	5,010	feet, no oil.
General Petroleum No. 2	3,500	feet, 100 barrels 31° B.
Nichols	3,800	feet, no oil.
Sudden	1,200	feet.
Zabala	3,800	feet, no oil.
General (Sisquoc)	2,800	feet, lots of water.

Santa Maria Field.

(Standard Oil Company.)

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1906.				
January	36	1	328,100	298
February	29	4	382,400	471
March	27	3	312,100	373
April	26	3	344,100	442
May	24	3	310,500	417
June	38	2	272,400	239
July	38	3	306,700	260
August	43	3	378,600	284
September	48	3	496,618	344
October	58	1	546,694	304
November	57	2	551,465	322
December	57	7	523,334	296
Totals	-----	35	4,753,011	
1907.				
January	61	3	468,430	248
February	63	-----	569,300	322
March	62	4	644,950	335
April	72	2	688,750	319
May	75	-----	698,300	300
June	81	9	681,811	281
July	78	1	758,835	314
August	79	3	694,510	283
September	74	1	737,900	332
October	76	4	725,550	308
November	81	4	691,000	285
December	84	6	800,100	308
Totals	-----	37	8,159,436	
1908.				
January	90	1	808,210	290
February	89	4	731,670	294
March	95	2	756,900	257
April	96	3	758,400	263
May	92	4	699,700	245
June	95	3	686,100	241
July	97	1	591,680	196
August	95	1	706,800	240
September	104	4	620,470	198
October	109	3	668,700	197
November	114	6	681,650	199
December	116	4	719,950	200
Totals	-----	36	8,430,230	
1909.				
January	114	3	738,900	209
February	88	1	467,835	190
March	115	4	668,300	187
April	116	1	688,700	97
May	119	7	647,620	77
June	124	5	608,000	163
July	126	2	662,815	169
August	127	2	619,450	157
September	128	2	619,480	161
October	131	2	620,650	155
November	132	2	585,985	148
December	133	3	618,580	150
Totals	-----	34	7,546,315	

Santa Maria Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1910.				
January	134		617,510	151
February	134	1	531,600	142
March	134	2	538,710	129
April	134	4	532,000	134
May	131	3	541,460	133
June	134	2	519,000	129
July	129	5	666,300	166
August	135		776,550	185
September	139		547,350	131
October	140	4	545,990	125
November	142	2	539,350	126
December	149	1	553,800	119
Totals		24	6,909,620	
1911.				
January	146	2	541,450	119
February	145	1	562,077	138
March	146		700,556	154
April	163	1	717,570	146
May	156		685,141	142
June	145	1	428,720	98
July	143		408,933	88
August	157	1	460,938	94
September	159	1	461,810	96
October	165	2	552,022	107
November	168		585,681	116
December	160	3	565,176	114
Totals		12	6,670,074	
1912.				
January	160	2	554,049	112
February	160		494,503	106
March	158	1	471,910	96
April	163	1	467,228	95
May	171	4	498,653	94
June	164	3	490,789	101
July	168	1	485,688	93
August	164	4	491,027	96
September	157	1	459,000	97
October	152	3	484,809	102
November	148	3	449,610	101
December	152		440,820	93
Totals		22	5,788,086	
1913.				
January	149	1	427,893	92
February	147	1	393,400	95
March	166		458,490	89
April	176		449,700	85
May	178	5	424,080	76
June	183	4	429,300	78
July	191	3	456,475	77
August	193		469,030	78
September	192		336,450	58
October	194		330,615	54
November	192		327,300	56
December	191	1	338,055	57
Totals		13	4,840,788	
Total completed		213		
Idle or abandoned		22		

Lompoc Field.

(Standard Oil Company.)

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1906.				
January	1	----	2,000	64
February	----	1	----	----
March	----	----	----	----
April	----	----	----	----
May	----	----	----	----
June	1	----	2,000	66
July	----	2	----	----
August	----	----	----	----
September	----	1	*2,500	83
October	2	----	5,900	95
November	2	----	14,500	413
December	3	----	19,500	210
Totals	----	4	46,400	
1907.				
January	3	----	7,800	84
February	3	----	1,800	21
March	----	----	----	----
April	----	----	----	----
May	----	----	----	----
June	----	----	----	----
July	----	----	----	----
August	----	----	----	----
September	2	----	12,000	200
October	6	----	19,500	118
November	7	----	22,000	105
December	7	----	26,700	126
Total	----	----	89,800	
1908.				
January	7	----	32,100	148
February	4	----	24,800	214
March	4	----	22,000	177
April	3	----	10,000	111
May	4	----	24,800	200
June	6	----	26,100	145
July	6	1	20,460	110
August	8	----	23,460	94
September	8	----	20,450	85
October	8	----	20,450	82
November	8	----	24,500	104
December	7	----	20,000	92
Totals	----	1	269,120	
1909.				
January	7	----	20,000	92
February	4	----	11,000	98
March	8	1	19,500	78
April	9	----	22,000	81
May	11	----	38,900	118
June	12	1	38,900	108
July	13	2	42,310	105
August	16	----	62,510	126
September	15	----	51,900	115
October	16	----	56,110	113
November	16	----	55,000	114
December	16	1	53,010	107
Totals	----	5	471,140	

*Completed well produced 2,500 barrels.

Lompoc Field—Continued.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1910.				
January	14		48,700	114
February	14		41,660	106
March	12		42,220	113
April	13	4	47,900	122
May	17		51,930	98
June	16		50,100	104
July	16	1	52,700	106
August	20		69,900	111
September	20	1	70,200	117
October	19		72,900	123
November	19		72,500	127
December	20		77,500	125
Totals		6	698,210	
1911.				
January	18		69,400	124
February	18		55,100	109
March	15		54,000	116
April	20	1	64,300	107
May	19		67,800	114
June	19		63,600	111
July	18		53,100	95
August	21		68,400	105
September	24	1	75,000	104
October	23	1	74,600	104
November	24	2	78,200	108
December	24		71,500	96
Totals		5	795,000	
1912.				
January	25		71,750	92
February	21		70,400	115
March	26		76,300	94
April	24		77,850	108
May	24		79,650	107
June	24	2	87,300	121
July	24		102,150	134
August	24		95,350	138
September	23	1	93,000	134
October	21		84,940	130
November	22		86,220	130
December	23		88,970	124
Totals		3	1,013,880	
1913.				
January	19		62,248	105
February	19		66,500	125
March	27		84,010	100
April	27	1	84,450	104
May	28		103,695	119
June	28		97,800	116
July	29		99,820	111
August	29		97,960	109
September	29	1	67,800	77
October	30		72,695	78
November	30		70,350	78
December	30	1	69,595	74
Totals		3	976,923	

Santa Barbara County.

Oil production and price.

Year	Barrels	Amount
1894	1,800	$1 00
1895	16,904	75
1896	39,792	90
1897	130,136	1 00
1898	132,217	85
1899	208,370	92
1900	183,486	90
1901	203,616	56
1902	230,440	79
1903	262,226	57
1904	790,000	56
1905	3,534,000	40
1906	4,876,000	25
1907	8,392,623	50
1908	8,847,589	50
1909	8,116,788	50
1910	7,682,555	50
1911	6,766,156	49
1912	6,862,719	56
1913	5,891,076	54

Companies Operating in Santa Maria Field and Vicinity.

Company	Location—Section, township and range	Wells completed	Gravity	Official address
Associated Oil Co.	25-9-33	--------	--------	Sharon Bldg., San Francisco.
Algonquin Oil Co.	Arroyo Grande	5	16.0	
Brooks Oil Co.	31-9-32	1	13.0	Santa Maria, Cal.
Brookshire Oil Co.	23-9-34	3	22.5	San Luis Obispo, Cal.
Bess Investment Co.	25-8-31	--------	--------	
Coblentz Oil Co.	19-9-33	--------	--------	
Cat Canyon Oil Co.	20-9-32	--------	--------	
Casmalia Petroleum Co.	9-35	1	10.0	Edna, Cal.
Escolle	--------	--------	--------	
Federal Oil Co.	8-33*	--------	--------	310 Sansome st., San Francisco.
Fugler Ranch Oil Co.	3-9-33	--------	--------	
Gato Ridge Oil Co.	33-9-32	--------	--------	
General Petroleum Co.	--------	--------	--------	
Harris (Graciosa) "H"	--------	--------	--------	
Ideal Oil Co.	22-9-33	--------	--------	San Luis Obispo, Cal.
Lompoc O. and S. Co.	9-7-33	--------	--------	
Los Flores Oil Co.	--------	1	10.0	
Mohawk Oil Co.	--------	--------	--------	
New Pennsylvania Oil Co.	19-9-33 30-9-32	6	24.0	Santa Maria, Cal.
Orcutt Oil Co.	28-8-34	5	20.0	Lompoc, Cal.
Olympian Oil Co.	--------	1	--------	Casmalia, Cal.
Oilfields Syndicate of California	8-33*	1	19.0	
Pacific Oilfields	28-8-34	6	19.0	350 California st., San Francisco.
Pinal Dome (A)	--------	30	--------	Santa Maria, Cal.
Pinal Dome (B)	26	6	--------	Santa Maria, Cal.
Pinal Dome (Wickeden)	--------	1	--------	Santa Maria, Cal.
Pinal Dome (Togganzini)	--------	1	--------	Santa Maria, Cal.
Palmer Union	23-9-33	6	14.0	609 Crocker Bldg., San Francisco.
Purisima Hills Oil Co.	15-7-33	--------	--------	616 Shreve Bldg., San Francisco.
Refiners and Producers	36-9-34*	11	22.4	354 Pine st., San Francisco.
Rice Ranch	19-9-33	12	29.0	668 Pacific Electric Bldg., Los Angeles.
Santa Maria Enterprise	31-9-32	--------	--------	708 Kohl Bldg., San Francisco.
Santa Maria Petroleum and Pipe Line	30-9-32	1	13.0	
Santa Maria Oilfields of California	23-9-33	4	11.0	
St. Helens Oil Co.	35-10-33	--------	--------	
Santa Barbara Oil Co.	7-31	--------	--------	935 State st., Santa Barbara.
Sudden Oil Co.	28-8-34	--------	--------	
Santa Maria Midway	9-32	--------	--------	
Treasure Oil and Realty Co.	19-9-32	2	24.0	503 Laughlin Bldg., Los Angeles.
Taft Petroleum Co.	--------	2	10.0	Casmalia, Cal.
Union Oil Company—				
Hill	7-33*	3	20.0	Union Oil Bldg., Los Angeles.
Fox	24-9-34	7	23.0	
Purisima	7-34*	14	20.0	
Folsom	25-9-34	8	23.0	
Eefson	8-34*	6	20.0	
Hartnell	23-9-34*	5	23.0	
Hobbs	24-9-34	9	24.0	
Newlove	9-34	41	25.0	
Bell	26-9-33*	4	15.0	
Santa Maria O. and G. Co.	9-34	13	20.5	
Santa Maria Oil Co.	19-9-33	5	24.0	
California Coast	9-34*	10	23.0	
Buell Ranch	21-7-32*	--------	--------	
Western Union	31-9-33*	39	25.5	402 Bradbury Bldg., Los Angeles.
West Oil Co.	30-9-32	1	--------	
Total	--------	274		

*Not subdivided by sections.

The amount of oil produced in 1913 by various companies is indicated by figures on pages 32, 35, 42 and 46.

FINANCIAL RESULTS DURING 1913.

Financial results in the Santa Maria, Lompoc, and Summerland fields combined, during the year 1913, as shown by twelve companies, producing 1,940,980 barrels of oil from 202 wells, are summarized as follows:

Capital. This figure can not be definitely determined, particularly the second item (property value), and any error here is apt to be on the side of an overestimate.

Cash paid for stock	$2,454,943 00
Property paid for stock	19,613,135 00
Total	$22,068,078 00

Dividends are difficult to determine as many concerns are close corporations, making no public reports, hence our figures may be slightly below the actual amounts. Records earlier than 1909 were not available:

1909, 4 companies	$894,125 00
1910, 5 companies	1,548,236 00
1911, 5 companies	1,000,141 00
1912, 6 companies	374,720 00
1913, 8 companies	500,976 00

Three companies have continuously paid dividends since 1909. The production in 1913 by the dividend paying companies was 2,838,000 barrels or 49 per cent of the field total. Other facts are shown in the table on page 10.

Life of wells in the Santa Maria field can not be very definitely described, from the scanty data we here present, but the rate of decline may be expected to be considerably above the minimum for California wells. Deepening of wells has frequently enlarged their production. Water troubles have not received the systematic attention they deserve but are undoubtedly more serious than is generally supposed. To some extent the situation has been handled as in Kern River (page 202) and with similar results, with the exception that damage has not progressed so far and can still be repaired if systematically attempted.

COST OF DRILLING.

Cost of drilling in the older portion of the Santa Maria field is very reasonable, owing to the brown shale (diatomaceous) formation which drills easily, and does not cave so badly as soft sand or clay.

Accounts of a group of fourteen wells, drilled since 1908, with Standard tools, show the following results:

Average depth, 3,500 feet; maximum, 4,161 feet; minimum, 2,772 feet.

	Per well	Per foot
Labor cost	$5,933 00	$1 69
Material cost	9,561 00	2 72
Totals	$15,494 00	$4 41

The figures on rate of drilling were not definite, but averaged 14 feet per day, one well going as fast as 29 feet per day.

Labor cost—

Driller	$6 00 per day
Tool dresser	4 00 per day

At another group of ten wells, averaging 2,875 feet deep, the rate of drilling averaged 10 feet per day, with averages of 6 feet and 18 feet on the slowest and quickest wells.

Amount of casing used at the two groups is shown on the following table:

Depth	Number wells	Depth		
		Av.	Max.	Min.
2,500+ feet	10	2,875	3,195	2,551
3,000— feet	14	3,500	4,161	2,772

Depth	16-inch				12½-inch			
	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.
2,500+ feet					8	542	1,069	298
3,000— feet	7	250	414	120	14	360	565	120

Depth	10-inch				8-inch			
	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.
2,500+ feet	10	1,597	1,768	1,074	10	1,096	2,179	431
3,000— feet	14	1,845	2,314	457	14	1,560	3,113	613

Depth	6-inch				4-inch			
	Wells	Av.	Max.	Min.	Wells	Av.	Max.	Min.
2,500+ feet	6	337	628	141	1	2,853		
3,000— feet	6	1,980	3,634	570				

COST OF PUMPING.

Cost of pumping wells at Santa Maria and Lompoc was not satisfactorily determined by our inquiry, but is indicated by the following figures:

4 wells, 1 year—	
Labor, pumping (3 men)	$4,117 00
Cleaning oil	1,017 00
Repairs to plant	2,354 00
Supplies	687 00
Teaming, etc.	456 00
Total	$8,631 00
Cost per well day	5 92

This group was easily operated as pumps last a year or more and wells seldom need cleaning. The high cost illustrates the disadvantage of a small operating unit.

Operating and repairs of other groups of wells cost as follows for one year:

Number of wells	Total cost	Cost per well day
6	$21,058 00	$9 64
13	38,900 00	8 20
20	17,449 00	2 39
30	40,243 00	3 68
48	19,031 00	1 09
122	56,673 00	1 27

SUMMERLAND REGION.

Location.

The Summerland oil field is located on the coast in Secs. 23 and 24 in T. 4 N., R. 26 W. The producing wells are pumped from piers extending out into the ocean.

Topography.

The topography of the region immediately north of the oil field consists of the foothills of the Santa Ynez Range, which are broken up by extensive deposits of stream gravels and alluvium. The Santa Ynez Range is rugged and intensely folded, and offers no great inducement for oil prospecting because of the metamorphosed character of the Tejon sediments and the steep folding of the exposed beds. Although some oil has been taken from these sediments in Oil, Toro, and Santa Monica canyons, the structure and lithology are unfavorable to extensive accumulations.

Geology.

The Sespe sandstone is a prominent horizon marker along the southern face of the Santa Ynez Mountains. This formation is exposed within about a mile of the coast northwest of Summerland, but is overlain by the Monterey formation between there and the coast. This strip of Monterey widens to the east and outcrops on both sides of the Santa Barbara terrace. The Monterey shale in places along the coast north of Santa Barbara exhibits a petroliferous character but no live seepages are reported. The brea deposits near Carpinteria issue from the Monterey shale exposed along the coast.

The oil at Summerland is obtained from the sands of the Fernando formation which has a southerly dip. The productive sands lie at depths ranging from 100 to 400 feet, depending upon their location down the dip of the beds. Seepages from the oil sands occur along a break in the beds just north of the coast. The oil pumped is of low gravity, being about 12° Baumé, and the wells are small producers. The oil is probably an accumulation from the underlying Monterey shale.

The most likely territory has already been developed in the Summerland field and in the region of Carpinteria. Whether the anticline one mile west of Montecito, and the Fernando southwest of Santa Barbara, will produce oil remains for the drill to prove.

Companies Operating in Summerland Field.

Company	Location	Wells operating	Official address
Appel, Geo.		9	
Baker, Geo.		51	
Bennett, Benjamin		9	
Duquesne		11	433 I. W. Hellman Bldg., Los Angeles.
Kern Trading and Oil Co.		10	
Lillis, J. C.		14	
Sunset		14	637 Consolidated Realty Bldg., Los Angeles.
Seaside		20	Summerland.
Total		138	

CHAPTER X.

Geology and Possibilities of Oil in Portions of Monterey, San Luis Obispo, and San Benito Counties.

By Clarence A. Waring.

INTRODUCTION.

Plan of Present Work.

Up to the present writing no complete geologic map has been published of the prospective oil territory of Monterey and San Luis Obispo counties. The general information therefore is scattered and an attempt will here be made to compile such results of former authors as seem correct, together with unpublished reports accessible and results obtained from reconnaissance work throughout the territory.

Acknowledgments.

The writer was accompanied during a week spent in preliminary examinations by Mr. R. P. McLaughlin, who outlined and directed the work. About three weeks were spent in the field from King City to San Juan. The geologic data of the Carrizo plain region is taken from maps and descriptions by Mr. R. P. McLaughlin and from a week's reconnaissance by the writer. The geology south and west of the San Juan Ranch to the south line of T. 29 S., R. 17 E., is taken from maps made by Mr. Bruce Martin under the direction of Mr. F. M. Anderson. The work of Mr. R. B. Moran, both maps and manuscript, in the county northwest of a line through Pleyto and Parkfield, was particularly useful.

Geography and Topography.

The Coast Range of California consists of a system of parallel mountain ridges having a general northwest-southeast trend. The most northeasterly range of this series is the Mount Diablo Range which with its system of parallel subordinate ranges extends from Mount Diablo, in Contra Costa County, to Mount Pinos, in Ventura County, where it merges into the complex mountain region west of Lion Pass. This range has a length of about 270 miles and an average altitude of 3,000 feet and forms a barrier between the San Joaquin and Salinas valleys.

On the southwest, the Santa Lucia Range separates the Salinas Valley from the Pacific Ocean. This range rises abruptly south of Carmel Bay and extends southeastward along the coast as an unbroken chain to Cuesta Pass, San Luis Obispo County. It has an average elevation of 3,500 feet. Diverging from the main range, the San Antonio Hills and Sierra de las Piedras form a 2,500-foot relief in the topography.

The area under consideration takes in most of the narrow portion of Salinas Valley and the Mount Diablo Range adjacent. The valley portion extends from Templeton on the south to King City on the north. The slopes on either side are cut by many streams and the topography is generally rounded off as a result of its former submergence.

GENERAL GEOLOGY.

Formational Distribution.

The sedimentary rocks of geological importance for the production of oil in Monterey and northern San Luis Obispo counties lie on either side of the Salinas Valley (as shown on Plates IV and V), and are included in the coast valley division of the state. In general the region is part of a great trough lying between the Mount Diablo Range on the northeast and the Santa Lucia Range on the southwest. A great fault on the northeast has produced a zone of fracture, in places a mile wide, and in this zone may be found an aggregation of Franciscan rocks and later sediments. The main mass of sediments dips gently on either side towards the Salinas River, but is sharply folded on the northeast and southwest by horizontal pressure against the granite core of the Santa Lucia range and the Franciscan rock of the Mount Diablo Range.

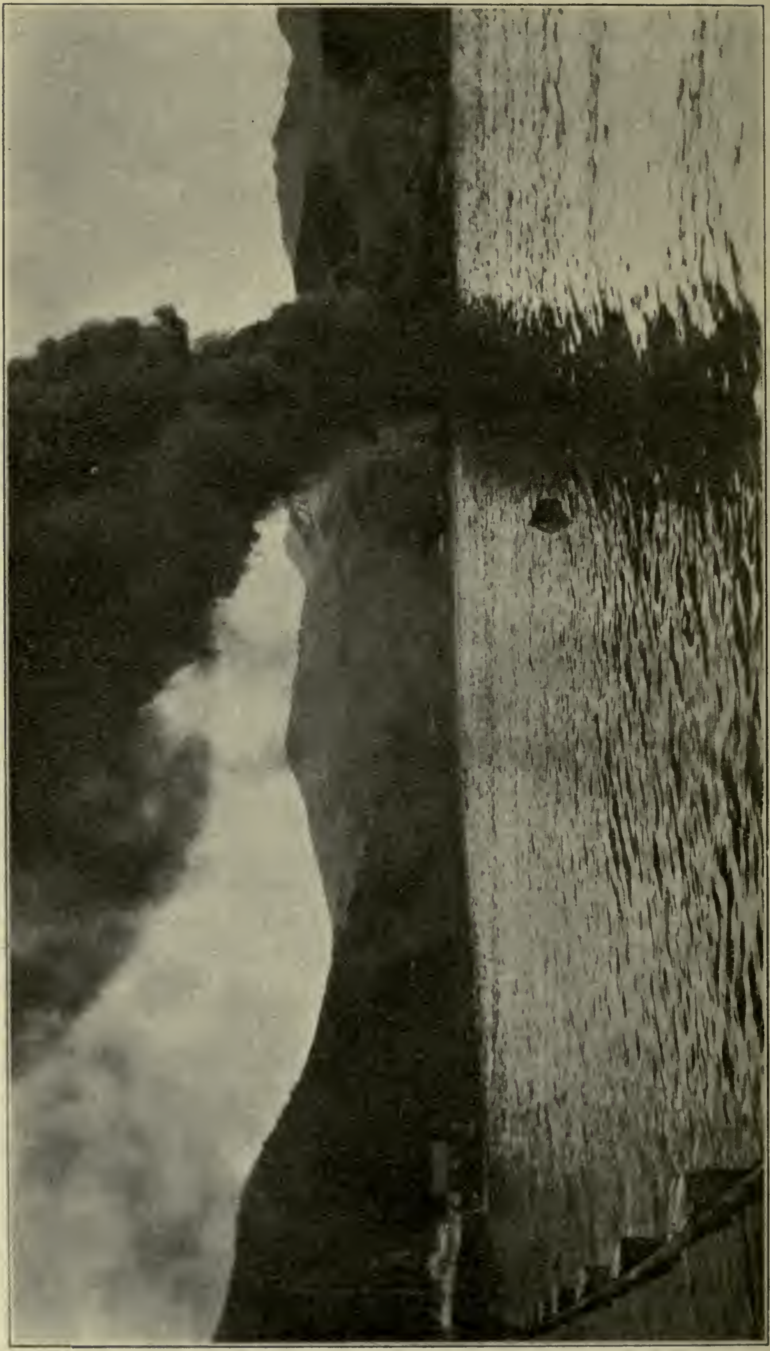
Structure.

The cross-sections A-B, C-D, E-F, and G-H, Plate VI show the structure of the region. These sections have been made from actual field observations through the regions where oil prospecting has been chiefly carried on. The general structure of the whole region varies but little. Cretaceous and Tertiary sediments rest on a basement of Paleozoic, metamorphic, and igneous rock.

Rocks Important with Relation to Petroleum.

Considerable unsuccessful prospecting has been done in this territory. Many wells have been put down in Monterey shale with no regard to geological structure and the position of oil horizons. As is shown by the accompanying geologic map, most of the drilling has been in the region of seepage, along fault lines and broken strata.

It is generally reasonable to expect the accumulation of oil, in quantities of economic importance, in anticlines where the oil-bearing formation is covered by impervious strata, or where a monoclinal oil-bearing stratum is overlain by impervious beds, and sealed at the outcrop by oxidation. The oil thus accumulated is often obtained by drilling into the beds at considerable depth down the dip.



A burning oil tank at Port San Luis. Photograph by R. B. Moran.

The oil seepages so far observed in this region have been in post-Monterey sandstones and fractured shales, which are suitable formations for oil flowage.

The seepages occurring are local and can not usually be traced for any great distance. The strata, in which the seepages occur, are usually of small thickness and not very well capped by clay or other impervious beds. The oil found thus far is of low gravity and is present only in small quantities. The indications serve as a stimulation to prospecting.

STRATIGRAPHY.

Basement Complex.

The basement complex on which the sedimentary rocks of the region rest, consists of Coast Range granite, gneiss, schist and marble, outcropping in the Santa Lucia and Mount Diablo ranges.

Franciscan Series.

The Franciscan formation consists of a series of metamorphosed sediments intensely folded and broken by pressure. The sandstones, cherts and conglomerates are very hard and usually outcrop in rugged topography. They are probably of Jurassic age and are referred to by Fairbanks (U. S. Geological Survey, Folio No. 101, p. 2, 1903) as the San Luis formation.

Serpentine.

Serpentine is an igneous intrusive rock, usually of a green color, and is usually associated with the Franciscan formation. Intrusions of this rock probably began after the Franciscan sediments were deposited and extended into the Cretaceous.

Cretaceous Formations.

Sediments of Cretaceous age have been mapped by Arnold and Johnson (U. S. Geological Survey, Bul. 406, Prel. Rept., on the McKittrick-Sunset Oil Region) in the Mount Diablo Range in the region about Polonio Pass. Similar sediments occur on the northeast side of the fault along Lewis Creek from Oak Canyon to about two miles east of Bitterwater Creek. The formation here consists of about 500 feet or more of carbonaceous gray shales and brown sandstones. They closely resemble the Chico formation as exposed in the Western Pacific Railroad cuts west of Altamont, Alameda County. Fossils collected from these shales are of Chico age and characteristic of the shales near Altamont.

Vaqueros, Monterey, and Temblor Formations.

The name Vaqueros formation is here used as originally applied by H. W. Fairbanks (Folio 101, U. S. Geologic Survey, p. 3, 1904) for those sandstones and minor interbedded shales in the western Coast Range below the heavy shales and minor interbedded shales of the Monterey formation. It is confined to sandstones and shales which are older than the Monterey shales and sandstones.

The Monterey sandstone (Temblor horizon) and Vaqueros sandstone have both been included under the one name, Vaqueros, in the Coalinga and McKittrick-Sunset regions by former workers in that region, although most of the so-called Vaqueros in that district belongs to the latter, or Temblor horizon. These two formations which are so much alike, lithologically, in the San Joaquin Valley region, are quite distinct nearer to the coast. It is probable that only the latter part of the Vaqueros period of sedimentation is represented further east, while a great thickness of the lower and older horizon is found near the coast.

The Vaqueros sandstone is made up of dark gray biotitic sandstone and is characteristically represented faunally by *Pecten magnolia* Conrad and *Turritella inezana* Conrad. It is interbedded with arenaceous shale.

The Monterey sandstone is of a white, yellow and red color, often not well consolidated and is characterized by different fauna at different horizons, although many of the fauna range through all the horizons. The sandstones are interbedded with Monterey shale. Characteristic fauna of the sandstone are: *Turritella ocoyana* Conrad, *Chione temblorensis* F. M. Anderson, and *Scutella merriami* F. M. Anderson. *Yoldia montereyana* Arnold is characteristic of the Monterey shale.

Santa Margarita Formation.

The Santa Margarita formation is characterized by white and light gray, heavy bedded, quartzitic sandstones, and white shales which resemble some of those in the Monterey series. About 100 feet from the base of the formation in Vineyard Canyon is a prominent fossil zone with an abundance of *Ostrea titan* Conrad and *Pecten estrellanus* Conrad. Only about forty feet of sandstone separates this fossil zone from the overlying shales which are 100 feet or more thick and are unconformably overlapped by fossiliferous, lower Jacalitos shales. Farther north in the region east of King City the fossiliferous horizon of the Santa Margarita formation includes *Tamiosoma gregaria* Conrad in addition to *Ostrea titan* Conrad and *Pecten estrellanus* Conrad.

Jacalitos and Etchegoin Formations.

The Jacalitos and Etchegoin formations include the sediments lying between the Santa Margarita formation and the fresh water Pliocene sediments of the Tulare or Paso Robles formation. West of Cholame Creek the Etchegoin consists of white and brown loosely consolidated sandstones and clayey shales, while in the Cholame Valley and eastward these lower sediments are overlain by blue, heavy and cross-bedded sandstones and shales, with *Nucula* (Acilia) *castrensis* Hinds. The Etchegoin formation is represented also in the region at the head of Indian Valley and Big Sandy creeks where it is only remnantal and consists of thick beds of loose sands with sand dune structure. The Etchegoin can not be separated lithologically from the Jacalitos, and probably only the lower part of the formation is represented. The Jacalitos is best represented on the west side of the divide between Salinas River and Cholame Creek, where it can be identified from the upper Santa Margarita by the presence of a characteristic fauna including such species as: *Trophon ponderosum* Gabb, *Modiolus rectus* Conrad, and *Phacoides annulatus* Reeve. The same horizon exists in Indian Valley, but it was not differentiated in mapping.

Tulare and Paso Robles Formations.

The name Paso Robles was used by H. W. Fairbanks (U. S. Geological Survey, Folio No. 101, p. 4, 1904) for some incoherent conglomerate and sandy and marly clays of fresh water origin, filling the middle Salinas drainage area and well exposed about the town of Paso Robles. The same formation can be followed eastward into the Carrizo plains where it has been included in the McKittrick (U. S. Geological Survey, Bul. No. 406, 1910) formation by Arnold and Johnson. It can be correlated, in part, with the Tulare Lake beds described by F. M. Anderson (Proc. Calif. Acad. Sci., 3d Series, Vol. 11, No. 2, p. 181, 1905). Specimens of *Macoma inquinata* Deshoyes were taken from a calcareous streak in the shales two miles northeast of San Miguel on the road up Vineyard Canyon, and Pliocene leaves were obtained from the upper part of the formation one half mile southeast of the town of Cholame. The formation dips gently towards the Salinas River from both sides and probably is not over 500 feet thick. The formation is characterized near the top by a hard bed of marl. Probably it can be correlated, in part, with the Orindan of the Mount Diablo region as F. M. Anderson suggests (Proc. Calif. Acad. Sci., 3d Series, Vol. 11, No. 2, p. 181, 1905).

THE SAN LORENZO DISTRICT.

Geology.

The San Lorenzo district includes the upper drainage basin of the San Lorenzo River in T. 19 S., R. 10 E., together with that of Lewis Creek in T. 18 S., R. 10 E. and T. 19 S., R. 10 E. Prospecting has been chiefly done near the San Andreas Rift and in the region about Lonoak and Peach Tree. Small seepages are said to occur along the rift in the Santa Margarita sandstone where it has been faulted against the Franciscan formation. The structure is shown in cross-section A-B. Most of the later Miocene sediments, which might form reservoirs for the oil, have been eroded away.

Wells.

The following companies have drilled wells in the district:

The Nonpareil Oil Company drilled two wells on the Alveras property in the SW. ¼ of Sec. 33, T. 18 S., R. 10 E. No. 1 was a dry hole 1,038 feet deep in blue shale. It was finished with 7⅝-inch casing. No. 2 was drilled 653 feet deep near a seep close to the fault. The drill is reported to have passed through 122 feet of oil bearing sandstone. At 450 feet it is claimed oil of 42° gravity was struck and about six gallons of oil per day bailed from the 7⅝-inch casing.

The Alvarez Oil Company drilled a 900-foot well near a seepage in the SW. ¼ of the NE. ¼ of Sec. 33, T. 18 S., R. 10 E. A 7⅝-inch casing was used and a trace of low gravity oil is reported.

The Lonoak Oil Company drilled a well in the SE. ¼ of the SW. ¼ of Sec. 32, T. 18 S., R. 10 E. At 1,200 feet some oil of 14° gravity was reported. Six-inch casing was used to a depth of 3,009 feet, then blue shale was struck. The well was abandoned. Another well was drilled to a depth of 2,700 feet with eight-inch casing in Sec. 8, T. 19 S., R. 10 E. Salt water was struck and the well abandoned.

The Salinas Oil Company drilled a well in Sec. 9, T. 19 S., R. 10 E. The hole is 1,200 feet deep in late Miocene sandstone and shale close to the fault. A small amount of low gravity oil was obtained.

A rig was erected on the NE. ¼ of Sec. 31, T. 18 S., R. 10 E. in 1902–3, but no drilling was done.

The Standard Oil Company did some prospecting southeast of Lonoak and near Peach Tree. All their wells were in the Santa Margarita shales and sandstones and are as follows:

The Powell Well No. 1 was drilled near the center of Sec. 1, T. 23 S., R. 11 E., to a depth of 875 feet. It was drilled near the top of the Santa Margarita formation and probably did not get through the shales at the top of that formation. The formation was soft and the well abandoned.

The Landrum Well No. 1 was drilled to a depth of 2,965 feet in the SW. ¼ of Sec. 28, T. 19 S., R. 10 E. The drill passed through 750 feet of Santa Margarita shales and sandstones with some limestone, 20 feet of shales showing a trace of oil, 1,150 feet of shale and sandstone, 15 feet of sand with some gas, 1,030 feet of gray and blue sands. Water was struck between 2,840 and 2,860 feet which filled the hole for 200 feet. The well probably did not get through the Santa Margarita formation.

Two wells were put down on the Tompkins property. No. 1 was drilled in the SW. ¼ of Sec. 19, T. 19 S., R. 10 E., in the alluvium. It struck the Santa Margarita formation at 170 feet and passed through shell, sand and shale to a depth of 1,794 feet, where it was abandoned. No. 2 was drilled to a depth of 1,600 feet in the NE. ¼ of Sec. 19, T. 19 S., R. 10 E. It passed through 1,030 feet of shale where 20 feet of water sand and a little tar were encountered. Below this only sandstone and shale were found and the well abandoned.

THE PARKFIELD DISTRICT.

Location.

The Parkfield district is confined to the upper drainage basin of Cholame Creek and embraces T. 23 S., R. 14 E., T. 23 S., R. 15 E., and that portion of T. 22 S., R. 14 E., which lies southwest of the Fresno-Monterey county line.

Structure and Geology.

The cross-sections E-F and G-H show the structure of the field. The axis of folding runs N. 60° W. The ridge to the northeast consists of Monterey sandstone, dipping to the north about 40°. This same formation continues northwestward and overlies the Stone Canyon coal beds. The sandstone is abruptly cut off by a great fault which has produced a fractured area over a mile wide, parallel with the axis of folding, along the southwest side. The faulted area consists principally of Franciscan rock and serpentine, but some small areas of Miocene sediments have been left isolated on the surface.

On the southwest side of this faulted area the Miocene sediments have been sharply folded and in places broken. In Sec. 15, T. 23 S., R. 14 E., the sandstone and shale have been faulted against the serpentine, and oil seepages occur along the exposed oil bearing sands of the Etchegoin.

The exposed sediments in the Cholame Valley are nearly all of Etchegoin age. Cholame Creek branches south of Parkfield. The eastern branch, Little Cholame Creek, heads in the faulted area and in places cuts through the Etchegoin and Santa Margarita formations into the underlying granite. The Miocene sediments are probably not over 1,500 feet thick and are sharply folded. The structure between the Cholame and Little Cholame Creeks is anticlinal, but the sharp folding has broken the oil sands in places and seepages occur.

On the west edge of the Cholame Valley some Franciscan rocks outcrop. The range to the southwest is a broad unbroken anticline of the

Santa Margarita formation underlain by Monterey shale. The Santa Margarita here consists of about 100 feet of blue to gray quartzitic sandstone overlain by 100 feet of shale which weathers white and resembles Monterey shale. The sandstone is in part cross-bedded and includes fossiliferous beds with *Ostrea titan* Conrad and *Pecten estrellanus* Conrad.

The anticline is well exposed at the head of Vineyard Canyon. Its axis runs N. 55° W. and it may be traced as far as Cholame on the southeast and Valleton on the northwest. A seepage has been reported at the head of Vineyard Canyon, but the writer was unable to find it. The folds in that region at least offer a possible place for oil accumulation.

Oil Horizon.

All the oil seepages observed in this district are in sandstones of the Santa Margarita and Etchegoin formations. Those in the Santa Margarita formation are at its base in granitic wash and sandstone, and are often at the granite contact. The structure seems unfavorable to the accumulation of large amounts of oil, for if the oil-bearing stratum were continuous a larger portion of the granite contact should be bituminized.

Wells.

The wells of the Parkfield District will be taken up in two divisions: those drilled near the fault, and those drilled along the anticline between Cholame Creek and Little Cholame Creek.

Wells drilled near the fault are as follows:

A dry hole in the SW. ¼ of the SE. ¼ of Sec. 18, T. 23 S., R. 15 E., was drilled by a Canadian company 250 feet into the Franciscan rock, 10-inch casing being used. No oil should have been expected in this formation.

The Future Success Company (A. A. Baker of Coalinga, president) is drilling a well in the NW. ¼ of the SW. ¼ of Sec. 18, T. 23 S., R. 15 E. The well is 1,315 feet deep in serpentine and Franciscan rock, with 6⅝-inch casing. Oil might possibly be found in the Etchegoin formation if the fault has thrust it so far to the east. In September, 1914, eight months after the above statement was written, a show of oil was reported at 1,860 feet.

The Parkfield-Spokane Company has drilled three wells on the southwest face of the fault plane in the SE. ¼ of Sec. 13, T. 23 S., R. 14 E. The wells are in the Etchegoin formation, which has been faulted against the Franciscan rock, and which dips N. 45° E. 45° into the mountains. Some oil has seeped out from the lower sandstone strata and the wells have been drilled on the side of the hill so as to pierce these oil sands at a greater depth. Results were as follows: Well No. 1 is in the NW. ¼ of the SE. ¼ of the SE. ¼ of Sec. 13, T. 23 S., R. 14 E. It is 110 feet deep, through sandstone into shale, with 5⅝-inch casing. About one barrel of oil of about 16° Baumé is being pumped daily.

Well No. 2 is in the center of the NW. ¼ of the SE. ¼ of Sec. 13, T. 23 S., R. 14 E. Some oil of 15.6° Baumé was obtained at a depth of 245 feet.

Well No. 5 is in the NW. ¼ of the NE. ¼ of the SE. ¼ of Sec. 13, T. 23 S., R. 14 E. It was started about 75 feet from the top of the sandstone exposure and drilled 513 feet through sandstone. Some tar sand was struck at 280 feet.

The Parkfield-San Antonio Oil Company drilled a well in the center of the SW. ¼ of the SW. ¼ of Sec. 31, T. 22 S., R. 14 E. At this locality a thin remnant of sandstone rests on the granite of the bedrock series and carries a little oil. The well was abandoned at a depth of 100 feet. A few gallons of seepage oil is said to have been bailed from the well after standing a year or so.

The Cholame Valley Oil and Development Company (Capt. Frank Barrett of Palo Alto, manager) drilled four wells in Sec. 31, T. 22 S., R. 14 E., and Sec. 5, T. 23 S., R. 14 E., M. D. M. These wells were all close to the fault, near seepages from remnants of late Miocene sediments on the granite. One well was drilled 950 feet through shale, decomposed granite and into granite. A small amount of 20° Baumé oil was struck at a depth of 130 feet. Other wells in like formation were drilled 800 feet, 200 feet, and 200 feet, respectively, and abandoned.

The Waverly Oil Company (Chas. King of Hanford, president) drilled an 800-foot well in Sec. 32, T. 22 S., R. 14 E., M. D. M. The Etchegoin and Santa Margarita formations were passed through and the shales of the Monterey drilled into. Gas was struck at 350 feet. It is close to the fault line.

Although some oil occurs as seepages from the sandstone in the vicinity of the fault, it is improbable that the formation is sufficiently extensive to form reservoirs of economic importance.

Wells drilled between Cholame Creek and Little Cholame Creek, along the anticline, are as follows:

The Tri-County Oil Company (James E. Taylor, Parkfield, manager) has drilled a well in the NW. ¼ of the SE. ¼ of Sec. 15, T. 23 S., R. 14 E. The surface exposure is Etchegoin sandstone, dipping N. 35° E. 75°, elevation 725 feet. The well has been sunk 4,100 feet with 4-inch casing, at which depth brown shale was struck. Some oil was struck at 2,630 feet and at 2,800 feet. Oil was also struck at 2,915 feet, and flowing salt water 20 feet deeper. The 4-inch and 6-inch casings were pulled, and an unsuccessful attempt made to cement off the water. A small amount of oil accumulates on the surface of the water in the well at the present time.

The Oak Shade Oil Company drilled a 1,000-foot well in the NE. ¼ of Sec. 8, T. 23 S., R. 14 E., using 6-inch casing. The well is in shale along the axis of an anticline, but starts below the oil strata. The oil sands of the anticline outcrop on both sides of the well and dip away from the well. Some oil seeps from the exposed beds on the northeast side. Several other seeps occur from these same beds farther northwest, where the streams flowing into the Little Cholame Creek cut across them. The well was taken over, in July, 1914, by the Monterey Oil Company, which is drilling it deeper. Heavy gas pressure is reported.

A well is being drilled on the southwest limb of the anticline in the SW. ¼ of T. 23 S., R. 14 E. A portable rig is being used and a 6-inch string of casing sunk. The locality is probably a favorable one if the oil stratum is continuous.

The Middle Ridge Oil Company has its rig started for a well about a mile and one half southwest of the Oak Shade well. The location, in Sec. 18, T. 23 S., R. 14 E., is on the southwest limb of the Middle Ridge anticline and some oil will probably be encountered.

Outlying Wells.

The Cholame Valley Oil and Development Company drilled a well 1,250 feet deep, using 8-inch casing, in the NW. ¼ of Sec. 16, T. 24 S., R. 14 E. A strong gas pressure was encountered. The well is below the Etchegoin oil horizon and probably passed through the underlying Santa Margarita into Monterey shale.

At Greenlaw's ranch, in Sec. 34, T. 23 S., R. 15 E., a small gas flow is obtained from a 6-foot hole. This is near the fault line and probably if there was any oil in the underlying strata it would show as seepages.

The Eureka Oil Company drilled an 800-foot hole in the NW. ¼ of Sec. 31, T. 22 S., R. 13 E. The well drilled down to granite on the east limb of the anticline and struck some stream gravels cemented by tar. A small accumulation of tar is reported near the well.

The Cedar Spring Oil Company is drilling a well on the San Juan Rancho about forty miles south of Parkfield in the SE. ¼ of Sec. 29, T. 28 S., R. 17 E. This well is near the end of the axis of an anticline of Santa Margarita sandstone pitching to the north. The well was started with 12½-inch casing. Quicksand was struck at 1,400 feet and the casing was reduced to 10-inch. Artesian water is being cemented off at a depth of 1,955 feet. No oil has been struck. Drilling is to be carried deeper by another company.

THE CARRIZO DISTRICT.

Location.

The Carrizo District includes that territory in San Luis Obispo County lying southeast of La Panza and bounded by the Temblor Range and the Santa Maria, or Cuyama River.

Geology.

The geologic map of the region (Plate V), together with the cross-sections K-L, M-N, and O-P, show the structural relations of the formations and the position of the San Andreas rift.

South and west of La Panza is a large area of granite which is overlapped about the borders by Vaqueros and Monterey sandstone. East of the granite area in the region west of San Juan Creek the Monterey sandstone dips to the east and is overlain by Monterey shale. The entire range of mountains, along the east side of Carrizo (or upper San Juan) Creek, and forming the western border of Carrizo plain, is made up of rocks of the Monterey series. These are folded with major structure along northwest and southeast axes, while minor folding has taken place along northeast and southwest axes. The range southeast of the Carrizo ranch is characterized by basaltic flows which are interbedded with the Monterey series and in places intrude it. Along the eastern and southern borders of the Carrizo plain, the Monterey series is overlain uncomformably by late Miocene sediments of probable Etchegoin age. The lower part of this formation consists of coarse conglomerate beds with granitic boulders and debris, overlain by coarse sandstone with pebbles of Monterey shale and fine grained sandy shale.

Oil Resources.

The basal Etchegoin sandstone beds are known to contain oil along the northeast border of the Elkhorn plain, where they outcrop. Wells drilled northeast of the outcrop have struck some oil but not in paying quantities. No seepages have been reported along the San Andreas rift. The only outcrop of sand carrying asphalt reported on the west side of the Carrizo plain is that north of the Cuyama River near the northwest corner of Sec. 36, T. 11 N., R. 28 W. In the Cuyama River, near the township line between ranges 27 and 28 W. (one half mile down stream from B. M. 1784 Santa Ynez Quadrangle) is an outcrop of oil sand and brea in sand and gravel, making up the mesas along the south side of the river. This series lies flat upon upturned edges of diatomaceous shale exposed in the river bottom and the hills in NW. ¼ of Sec. 25, T. 11 N., R. 28 W. (McKittrick Quadrangle). The shale dips to the northeast as do the overlying sand and clay beds extending to the summit of the range. These overlying beds contain a thick bed of large Ostrea in

Mocalitas Canyon near the northwest corner of Sec. 24, T. 11 N., R. 27 W. The nature of the formation here would probably not permit the retention of large amounts of oil.

South and west of the Cuyama River the mountains are composed principally of metamorphic and igneous rocks.

Wells.

The two Smith wells were drilled along an anticline of Monterey sandstone, southeast of San Diego Joe's. One of these is near the northwest corner of Sec. 22, T. 30 S., R. 20 E., and the other near the northwest corner of Sec. 16, T. 30 S., R. 20 E. Only traces of oil were struck.

The Erume well was drilled 200 feet into the faulted zone, near Sulphur Spring fault, through the Monterey shale into the Monterey sandstone of Sec. 15, T. 31 S., R. 21 E. Some light oil was obtained but not in paying quantity.

The Recruit well was drilled 1,530 feet into the Monterey sandstone, or possibly in faulted formation. No oil was obtained.

The Humauma well was drilled 2,300 feet into the Monterey sandstone. Only a trace of oil was obtained.

The Vishnu, or Sperry well struck some oil but has never produced enough oil to market. It is drilled on a monocline in the Monterey formation.

THE ARROYO GRANDE, EDNA, AND HUASNA DISTRICTS.

Location.

The Arroyo Grande, Edna, and Huasna districts are located south and southeast of San Luis Obispo. They include the area south of San Luis Valley drained by the San Luis Obispo and Pismo creeks, together with the drainage basins of the Arroyo Grande Creek and Huasna River.

Geology.

The same geologic formations represented in the Arroyo Grande region have in a nearby area been studied and described by the United States Geological Survey (U. S. Geological Survey, San Luis Folio 101, 1904). The formations important to the oil industry are the Monterey diatomaceous shale and the overlying Pismo and Paso Robles formations. The oil is supposed to have originated in the Monterey shales and accumulated in the reservoir afforded by the thick beds of loosely consolidated sandstone of the Pismo formation. At the asphalt mines three fourths of a mile south of Edna the oil impregnated sandstone forms prominent topographic features because of its weather resisting qualities. The Pismo formation covers a strip of territory extending four or five miles northeastward from the coast and from Arroyo

Grande Creek on the southeast to San Luis Obispo Creek on the northwest. The structure of this Pismo sandstone area is that of a broad syncline and the asphalt rises along the dip of the beds and seeps from the exposed sandstone on both sides of the syncline.

For five miles in an air line east from Arroyo Grande the formation is Monterey shale, which strikes due east and dips from 10° to 80° to the north. The formation for one and one half miles farther east is Franciscan rock and serpentine. Monterey shale again comes in about one half mile west of Tar Spring Ranch and extends for two miles farther east where the underlying Monterey sandstone is exposed and covers nearly all the country from there to the Porter Ranch, on Huasna River, with the exception of small remnantal areas of fossiliferous Monterey shale containing numerous impressions of *Pecten discus.* The rocks east of the Huasna River belong to the Monterey series and are folded and faulted along an axis running N. 25° W. A considerable area of the Santa Margarita formation, lying in the trough of a syncline, is reported northwest of the Porter ranch. This syncline has been tested by wells drilled by the Associated Oil Company, but no oil in paying quantity was encountered.

Wells.

The only wells operating in the whole region, at the present time, are those which formerly belonged to the Tiber Oil Company, two and one half miles south of Edna. These wells are at present sublet to the Spokane-Parkfield Oil Company, which is pumping wells Nos. 1 and 5 which are just west of Pismo Creek. Some oil is being forced from well No. 7 by the natural gas pressure, but the casing is collapsed and it is said that the well will eventually be abandoned. Well No. 4 is being cleaned out and will be pumped. Wells Nos. 2 and 3 have been abandoned. A new well is being drilled farther to the north. The wells range from 1,100 to 1,400 feet in depth. The oil is of about 12° Baumé. Arrangements are being made to sell the oil to the California Liquid Asphalt Company, which has a distilling plant a quarter of mile southeast of the asphalt mines and is at present using oil from Cat Canyon.

The Union Oil Company drilled two wells in the Monterey shales near Arroyo Grande. The oil was heavy and was not in sufficient quantity to be of economic importance. Union No. 1 was drilled one half mile N. 25° W. of Arroyo Grande, and Union No. 3 was drilled one quarter of a mile N. 50° E. of Arroyo Grande, both in what would be Sec. 22, T. 32 S., R. 13 E., were the land subdivided. Union No. 2 was drilled one mile S. 75° E. of Pismo on the north side of the county road in what would be Sec. 13, T. 32 S., R. 12 E., were the land subdivided.

Three wells have been drilled northeast of Avila. The Walker well No. 1 was drilled into Monterey shale and has given rise to Sycamore Hot Springs. No oil was struck.

The Jack No. 1 well was drilled in the northwest corner of Sec. 28, T. 31 S., R. 12 E. The hole started in the Pismo formation, but no data as to its log could be obtained.

The Barrett well No. 1 was drilled in the NW. ¼ of the SW. ¼ of Sec. 20, T. 31 S., R. 12 E. The well was drilled in Monterey shale and no oil obtained.

Other wells have been drilled in the Monterey shale of the region, but have been abandoned.

In the Huasna region several wells have been drilled in the Monterey series.

The Doheney well No. 1 was drilled 875 feet deep on Tar Spring Ranch in what would be about the northeast quarter of Sec. 22, T. 32 S., R. 14 E., were the ranch surveyed in accordance with surrounding lands. The well yielded only gas. Considerable asphalt has flowed from the shales along Tar Spring Creek. There is no formation overlying the shale in this region to form a reservoir in which the oil might accumulate.

The Stieger well was drilled, at an elevation of 1,000 feet, on the northeastern part of the Porter estate in what would be the SW. ¼ of Sec. 35, T. 31 S., R. 15 E. were the estate surveyed. It is about 1,100 feet deep and some water at present flows from the casing. No oil was struck. The well is located on the apex of an anticline of Vaqueros sandstone, the axis of which strikes N. 15° W. This same anticline continues southward and is overturned, and faulted on the east flank, in the region of the Harkness wells, one mile east of the Porter ranch house. The Vaqueros sandstone is overlain by Monterey shale on the west flank of the anticline.

The Harkness wells, Nos. 4 and 5, are located in what would be the western part of Sec. 13 and the eastern part of Sec. 14 of T. 32 S., R. 15 E., were the estate surveyed. They are now known as the Squires wells, and were drilled about 800 feet deep. A little gas was encountered. The Majestic and New Huasna No. 1 wells were drilled through the Monterey shale in the same section but farther west than the Harkness wells. No oil was struck by either of these.

The Harkness wells, Nos. 2 and 3, are located on the Porter estate in what would be the southwest corner of the SW. ¼ of Sec. 22, T. 32 S., R. 15 E. They were drilled less than 1,000 feet deep and abandoned. No oil was struck.

The Downer wells, Nos. 1 and 2, were drilled in the SE. ¼ of Sec. 31, T. 32 S., R. 16 E. No oil was encountered.

STATISTICS OF FIELD DEVELOPMENTS.

Arroyo Grande Field.

(Standard Oil Company.)

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1906.				
January				
February				
March				
April				
May				
June				
July		1		
August				
September	1		1,000	
October				
November			*1,000	
December		1	†1,000	
Totals		2	3,000	
1907.				
January			*1,000	
February			*1,000	
March		1	*1,200	
April				
May		1	*2,000	
June				
July	2	1	4,000	
August	2	1	8,000	
September	3		8,000	
October	4	1	10,900	
November	6		7,000	
December	2		4,000	
Totals		5	47,100	
1908.				
January	4		8,300	
February	5		4,000	
March	1	1	2,625	
April	3		5,400	
May	2	1	5,800	
June	6		10,750	
July	4		10,000	
August	4		10,000	
September	3		8,000	
October	4		10,000	
November	4	1	8,000	
December	5		7,500	
Totals		3	90,375	
1909.				
January	3	1	5,000	
February	6		7,900	
March	6		9,100	
April	6		9,000	
May	4		7,000	
June	6		6,000	
July	6		5,270	
August	4		2,015	
September	4		2 250	
October	5	1	3,980	
November	5	1	3,550	
December	3		1,930	
Totals		3	62,995	

*Pumped for a few days.
†Production completed well.

Arroyo Grande Field—Concluded.

Year	Wells producing	Number of wells completed during month	Monthly production, barrels	Barrels per well per day
1910.				
January	3		2,360	
February	3		1,600	
March	3		1,620	
April	2		900	
May	2		930	
June	2		900	
July	2		700	
August	2	1	900	
September	2		900	
October	6		3,700	
November	6		3,800	
December	6		4,000	
Totals		1	22,310	
1911.				
January	5		3,200	
February	2		1,000	
March	2		1,300	
April	5		2,900	
May	4		2,200	
June	2		1,200	
July	2		1,200	
August	2		1,000	
September	2		1,000	
October	2		900	
November	4		1,950	
December	5		2,650	
Total			20,500	
1912.				
January	4	1	1,750	
February	1		100	
March	1		100	
April				
May				
June				
July				
August				
September				
October				
November				
December				
Totals		1	1,950	

THE SAN ARDO DISTRICT.

Geology.

Drilling one and one half miles southwest of the town of San Ardo has been confined to a strip one half mile wide, running N. 30° W. The area follows an outcrop of Santa Margarita sandstone which dips N. 65° E. 70° to 80° and carries a 6-foot bed of sand impregnated with bitumen. It is underlain by Monterey shale and is covered on the northeast by the alluvium of the Salinas River. Traces of oil, only, have been obtained from wells most favorably located, and the territory offers but slight inducement.

Wells.

The following companies have drilled wells in the territory:

The Tomboy Oil and Improvement Company drilled a 1,325-foot well in the NW. ¼ of the SE. ¼ of Sec. 19, T. 22 S., R. 10 E., on the Dudley place. A 5⅝-inch string of casing was used and some oil struck. The casing was pulled in 1901. The same company drilled a 700-foot well in the NE. ¼ of the NW. ¼ of the same section, on the Jergesen place, in 1900. A 7⅝-inch casing was used and no oil struck. Two wells were drilled in 1908-1909, on the Cook place in the SE. ¼ of the SW. ¼ of Sec. 20, T. 22 S., R. 10 E. They are known as the Doheney wells. One of these was 1,000 feet deep, the other 1,135 feet. Only traces of oil were encountered.

The San Antonio Oil Company, in 1901, started a well in Sec. 20, T. 22 S., R. 10 E., M. D. M. The drill was in river gravel for 700 feet when the hole was abandoned.

The San Ardo Consolidated Oil Company drilled wells 846 feet and 1,000 feet deep, respectively, in Sec. 12, T. 22 S., R. 9 E., M. D. M. and Sec. 6, T. 22 S., R. 10 E. Some oil is said to have been struck in the first of these between the depths of 560 feet and 630 feet. Below this depth shale was encountered.

The Norman Oil Company drilled a well in Sec. 4, T. 23 S., R. 10 E. in 1901. Traces of oil were reported between 500 feet and 600 feet.

THE BRADLEY-PLEYTO DISTRICT.

Geology.

The Bradley-Pleyto district may be considered a continuation of the San Ardo district southward. Prospecting has mostly been carried on along an outcrop, one half mile wide, of the Santa Margarita formation, which runs N. 35° W., six miles southwest of Bradley. The formation is cut by the San Antonio River. Brea deposits occur along the base of the outcrop which is underlain by Monterey shale and sandstone. The structure is shown in section C-D.

Oil in paying quantities may possibly be struck in this district if deep wells are sunk far enough east of the Santa Margarita outcrop.

Wells.

The following companies have drilled wells in the district:

The Bradley Oil Company (H. A. King of San Francisco, president) is drilling a well in the southwest corner of Sec. 36, T. 24 S., R. 10 E. About 800 feet have been drilled into the Paso Robles formation.

The Metropolis Oil Company (John I. Hoff of Oakland, president) has drilled a well in the SE. ¼ of Sec. 35, T. 24 S., R. 10 E. The well is drilling into the Paso Robles formation, hoping to strike the Santa

Margarita oil horizon below. The company is planning on drilling a new well in the SE. ¼ of Sec. 24, T. 24 S., R. 10 E.

The Caranaugh well was drilled in 1905 by Mr. Caranaugh. It is located in Monterey sandstone west of the Santa Margarita formation and passed through several beds of sandstone. No attempt was made to shut off the water and the well was drilled to a depth of 1,500 feet. A small amount of oil sand was passed through.

The Nacimiento well was drilled by Los Angeles parties in 1901 (W. A. Brophy, manager). The well is located in the Paso Robles formation just east of the Santa Margarita outcrop. The well struck the oil sands at the base of the Santa Margarita formation at a depth of 700 feet. The oil was too heavy to pump. The Santa Margarita formation apparently flattens out towards the east.

The Great American Oil Company drilled a well in Sec. 2, T. 25 S., R. 10 E. The well passed through the Santa Margarita formation and into the Monterey shale without striking productive oil sand.

The White Oaks Oil Company drilled an 800-foot well in the NW. ¼ of the SW. ¼ of Sec. 35, T. 24 S., R. 10 E., in 1902. The well is located near the outcrop of brea, and the oil sand was struck at 300 feet. The oil was too heavy to pump.

The Monterey Oil Company drilled a well in the NE. ¼ of the NW. ¼ of Sec. 34, T. 24 S., R. 10 E. It was drilled all the way in Monterey shale and was a failure.

The Pleyto Oil Company drilled a well in the SE. ¼ of Sec. 26, T. 24 S., R. 10 E. The well is 3,250 feet deep and passed through 3,100 feet of sand and brown shale, 87 feet of sand showing traces of oil, 30 feet of shell and sand, 20 feet of clay with gas, 13 feet of hard sandstone. The 4½-inch casing was cemented at 3,165 feet. The well is caved below this depth.

SUMMARY OF THE OIL POSSIBILITIES OF PORTIONS OF MONTEREY, SAN LUIS OBISPO, AND SAN BENITO COUNTIES.

The oil of the area occurs in the sandstones of the Monterey, Santa Margarita and Etchegoin formations (see Plates IV and V). Seepages occur where the oil-bearing strata are broken by faults, or are cut by erosion of the crests of anticline. Some of the sandstones impregnated with bitumen are used locally for road making and bridge surfacing. Erosion has carried away much of the late Miocene and Pliocene strata in which oil might accumulate and in places only small remnants of the oil bearing formations are left, overlying the shales from which the oil probably originated.

The San Lorenzo District has not yet been thoroughly prospected. The territory about Peach Tree is probably deep because of the great thickness of the Santa Margarita shales. It is possible that some oil may be obtained farther to the southeast where favorable structure is found, although no seepages have been reported. The territory along the fault, where drilling has been done near the San Lorenzo River, is believed to contain no oil of economic importance.*

The Parkfield District, so far as geological evidence and test holes show, presents a field of questionable economic importance. The oil sands are in the Etchegoin formation, which is not extensive and is considerably folded and faulted. The structure of the formations in the region does not indicate the presence of large reservoirs for oil accumulation, judging by the nearest productive fields. The field on the northeast side is cut off by the San Andreas rift. On the southeast side of Cholame Creek the Franciscan rock is faulted upward so that the best possibilities lie between the Cholame and Little Cholame creeks where small amounts of oil will probably be obtained. Southwest of the Cholame Creek, Monterey shale is in places exposed along the axis of an anticline in the Santa Margarita formation. No seepages have been reported in this region and no wells have been drilled, but the presence of the Santa Margarita formation suggests continuity between this anticline and the fields west of the Salinas River. It is also possible that oil bearing sandstone may underlie the Monterey shales, although no seepages are reported in the Monterey sandstone exposed in the Santa Lucia Range west of the Salinas River.

The territory southwest of Cholame Creek and north of Estrella Creek is covered with late Miocene sediments and is gently folded. A small seepage is said to occur in Sec. 20, T. 26 S., R. 16 E., which shows that some oil probably underlies this region.

The territory south of San Juan ranch is considerably folded and apparently the most favorable locality has been well tested by the Cedar Spring well. It is possible that some oil may be found in the Monterey sandstone underlying the Monterey shale north of La Panza, but no seepages are reported. No seepages are known to occur in the range of mountains extending southeastward along the southwestern border of the Carrizo Plain and the structure and presence of basaltic intrusions is extremely unfavorable for the accumulation of economic quantities of petroleum should such be present. The anticline northeast of the Santa Maria River is partly eroded and the small brea deposit exposed in Sec. 26, T. 11 N., R. 28 W., is thought to be remnantal.

On the southwest flank of the Temblor Range some oil has been obtained by wells in the Monterey sandstone. The oil is of good gravity but probably will not be found in commercial quantities, owing to intense folding and faulting. Some oil may possibly be found east of the San Andreas rift in the region of the Panorama Hills; however, the Humauma well was unsuccessful although located in a favorable locality to test the neighborhood.

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*Since the manuscript of this publication went to press the U. S. Geological Survey has issued Bulletin 581-D, covering "The Geology and Oil Prospects in Waltham, Priest, Bitterwater, and Peach Tree Valleys." Their economic conclusions are similar to our own.

The Arroyo Grande, Edna, and Huasna districts may possibly produce a small amount of oil. The Squires wells of the Huasna district were well located to test the Vaqueros sandstone for oil and therefore on account of their failure oil will probably not be found in commercial quantities below the Monterey shale in this region. The Union wells near Arroyo Grande indicate the futility of trying to obtain oil in commercial quantities from the Monterey shale. The old Tiber wells south of Edna show that heavy oil can be recovered from certain parts of the Pismo sandstone where it overlies the Monterey shale. Probably further drilling in geologically favorable localities within the area of Pismo sandstone will develop considerable heavy oil in the future.

In the San Ardo District drilling has been carried on close to an outcrop of Santa Margarita oil sand which dips steeply to the northeast. The wells have probably not fairly tested the sands, for most of them have been drilled near the outcrop. If deep wells should be drilled farther to the northeast, oil of higher gravity might possibly be obtained.

The Bradley-Pleyto District has been well prospected in the region of the exposed Santa Margarita oil sands and so far the oil has been found too heavy to pump. No drilling has been done farther to the northeast where a southerly extension of the San Ardo monocline might be expected.

San Luis Obispo County.

Oil production and price.

Years	Barrels	Price per barrel
1907	48,127	$0 35
1908	10,000	50
1909	30,000	50
1910	22,310	50
1911	38,092	63
1912	2,129	69
1913		

CHAPTER XI.

ALAMEDA COUNTY.

Prospecting for oil was carried on in Alameda County in the region between Tesla and Altamont and eastward, in townships 2 and 3 south, ranges 3 and 4 east, M. D. M.

The topography of the region rises to an elevation of about 1,000 feet above the floor of the Livermore Valley to the west. Most of the area is under cultivation and easy of access.

Geology.

The formations exposed south of Tesla consist of Franciscan chert and sandstone overlain by Horsetown and Chico sandstones and shales which dip to the north. In Corral Hollow brown sandstone and shale of Eocene (Ione) age are exposed, which dip very steeply. The lowest Eocene clays which rest unconformably on the Chico formation have furnished clay for the pottery works east of Tesla.

Overlying the Cretaceous and Eocene sediments north of Corral Hollow are the Briones and Santa Margarita formations, consisting of sandstone and marl and of coarse sandstones and conglomerates, grading upwards into finer grained bluish sandstones and shales.

The Jacalitos and Etchegoin formations consist of blue sandstones, clays, and rhyolitic conglomerates, probably partially of æolian origin. These deposits overlie unconformably all the older formations and cover them as a mantle, north of Corral Hollow between Carnegie and Midway.

Any oil occurring in this region probably originates in the shales of Cretaceous and Eocene age, and may accumulate in favorable reservoirs of the Briones, Santa Margarita, Jacalitos and Etchegoin formations. Etchegoin sandstone impregnated with light oil was noticed in the road cut seven tenths of a mile northeast of Tesla.

Wells.

The Standard Oil Company drilled two wells, one just north of Altamont in Sec. 28, T. 2 S., R. 3 E., and one in the NW. ¼ of Sec. 27, T. 2 S., R. 3 E. Cretaceous shale and sandstone were penetrated, but the depths and results of the wells are not known, aside from the fact that both are abandoned. Such an outcome was quite logical and is another instance illustrating the fact that geologic information is frequently as good and much cheaper than that obtained by drilling wells.

The Daisy well, one and one half miles east of Midway, in Sec. 33, T. 2 S., R. 4 E., encountered no oil. It was started in alluvium near the Etchegoin contact. An artesian flow of water is at present coming from the well.

The Fifteen Three Oil Company drilled two wells in the south half of Sec. 15, T. 3 S., R. 3 E. The holes were started in the Santa Margarita and Etchegoin sandstones and shales and are reported to have been drilled to depths of 600 and 1,400 feet. Water was encountered at a depth of about 300 feet and sand with traces of 32° gravity oil was reported at 500 feet.

The Tesla Coal Company drilled three, or more, wells on the north side of Corral Hollow in Sec. 25, T. 3 S., R. 3 E., and Sec. 29, T. 3 S., R. 4 E., M. D. M. They were drilled near the Eocene-Etchegoin contact to depths ranging between 800 and 1,000 feet. It is reported that no oil sand was encountered.

Other wells have been drilled northeast of Tesla near the western border of San Joaquin Valley, but no data concerning these wells is available.

Possibilities.

Of the region under consideration probably that presenting any possibilities lies only north of Carnegie where the Etchegoin formation is unbroken and covers the area with gentle dips. If this area is underlain by the oil-producing formations there is a possibility that small amounts of oil may have accumulated in favorable reservoirs in the Etchegoin beds. Thus far, however, developments have failed to show the presence of any considerable bodies of oil.

BUTTE COUNTY.

While there are no known oil indications along the eastern border of the Sacramento Valley, the following press bulletin is worthy of publication because it calls attention to the characteristics of oil and of iron oxide floating on water. The latter is frequently mistaken for oil by persons not skilled in geological work.

"An investigation by the United States Geological Survey of supposed oil territory near Oroville, California, has given negative results, the oil 'showing' on the surface of water having been found to be caused by the presence of iron oxide.

"The so-called oil seeps in the vicinity of Oroville, about which some inquiries have been made, prove to be mainly stains of iron and are not indications of petroleum, according to Geologist R. W. Pack, of the Survey, who examined them in December, 1913. These 'seeps' occur on the gravel-covered mesa that lies on the north side of Feather River opposite the city of Oroville. They consist of bright iridescent colors on the surface of small pools of water and of dark stains on the ground, mainly near such pools. The colors are caused by a film of iron oxide on the surface of the water, which produces an appearance similar to that formed by a small quantity of oil. It may be distinguished from an oil film by the fact that it is readily broken into small fragments when the pool is gently stirred, whereas the colors of an oil film reappear unbroken when the pool is again quiet. Pools covered by such a coating of iron oxide are plentiful and are especially noticeable in the old gravel mines north of Oroville. The black stains on the ground are similar to those appearing about small pools in almost any undrained area. They contain no trace of oil.

"Beneath the gravel that covers the mesa north of the river are beds of sand and clay that contain some carbonaceous matter which locally forms small beds of coal. Small amounts of gas or even traces of oil occur in beds of this type in many parts of the world, and such small pockets of gas as were found in the well drilled to a depth of 1,000 feet about five miles north of Oroville probably occur scattered through the beds. It is very improbable, however, that larger bodies of oil or gas will be found here."

COLUSA COUNTY.

Some oil is known to occur in Colusa County, and as early as 1865 prospect wells were drilled without success. The following description of geologic conditions is made up largely from information gathered by J. H. Menke, Jr., in the course of professional work, supplemented by facts outlined in Bulletin 19, California State Mining Bureau, and observations by the author in neighboring localities.

The oil region lies some ten or fifteen miles west of the town of Williams, which is on the Southern Pacific Railroad. A stage line passes through the region from Williams to Sulphur Creek. Areas of principal interest are in T. 15 N., Rs. 4 and 5 W., and T. 14 N., R 5 W.

The formations exposed are the Franciscan (metamorphic), which makes up a large part of the Coast Range, and the overlying Cretaceous sediments which dip steeply to the east, away from the mountains.

The strike of the beds is uniformly N. 5° W. and the dip gradually steepens in traveling westward toward the mountains; in section 21, T. 15 N., R. 4 W., it is 35°, at the southwest corner of section 19 it is 55°, and in sections 15 and 16, T. 14 N., R. 5 W. it is 70°. The total thickness of the beds therefore reaches the enormous sum of more than four miles (24,000 feet). The lower portion, about 16,000 feet thick, is composed of dark colored clay shale with beds of gray sandstone (Knoxville formation). At the top of the shale formation is a conglomerate bed (northwest corner section 30, T. 15 N., R. 4 W.), thence upward the series is composed principally of massive, yellowish sandstone containing hard, round, brown concretionary boulders which are characteristic of the upper Cretaceous or Chico beds.

At the base of the Knoxville beds, or top of the Franciscan, in T. 14 N., R. 5 W., particularly along Bear Creek in sections 21, 27, and 35, are numerous oil seepages and gas emanations.

The following wells have been drilled with no economic production:

Name	Section	Quarter	Township	Range	Date	Depth	Results
Williams No. 1	16	SE.	15	4	--------	2,800	Nothing.
Williams No. 2	18	NE.	15	4	1,903	810	Trace.
Williams No. 3	18	NE.	15	4	1,903	1,835	Oil and gas.
Williams No. 4	7	SE.	15	4	--------	750	Trace.
Williams No. 5	18	SE.	15	4	1,909	1,390	Gas blow out; trace of oil.
	17	NE.	15	4	--------	800	Nothing.
	10	NW.	14	5	--------	1,100	Nothing.
	21	--------	14	5	--------	800	Trace
	21	--------	14	5	--------	1,100	Trace
	27	SW.	15	4	--------	200	Nothing.
Herron	27	SE.	15	4	--------	--------	
Herron	35	SE.	14	5	--------	900	Seepage.
	7	SE.	13	3	--------	543	No oil.

It will be noted that the wells have tested the land near the seepages and also some of that higher up in the formation.

There is little or no reason to believe that the region will be productive, as the beds dip so steeply that if there were any oil contained it would almost certainly manifest itself at various places along their outcrop. Furthermore, the reported seepages are all close to the contact with the Franciscan series, and even if the nearby test wells had been productive, the oil sand would be beyond the reach of a drill a very short distance east from the croppings.

Gas is reported at the Elgin quicksilver mine and also at Wilbur Springs. Bituminous matter is reported in the Manzanita quicksilver mine at Sulphur Creek.

CONTRA COSTA COUNTY.

The occurrence of oil has been known for many years in Contra Costa County, about four miles northeast from Berkeley (about section 27, T. 1 N., R. 3 W.), on the Miner Ranch. The first drilling was done in 1864. There is but little reason to suppose that oil will be produced in paying quantities.

A brief description of geology and development was made by Ralph Arnold in 1907 (U. S. Geological Survey, Bulletin 340, p. 340), from which the following quotation is taken:

"*Geology and Structure.*—The principal structural feature in the region of the Miner Ranch is a southeastward plunging anticline which crosses Lauterwasser Creek just east of the ranch house. Along the axis of this fold the following formations are exposed in order, beginning a mile or so northwest of the field and extending to its southeast edge: Tejon (Eocene) sandstone; 200 feet of brown sandstone, possibly Vaqueros (lower Miocene); 800 feet of Monterey (middle Miocene), 300 feet shale and 500 feet sandstone, in which are intercalated minor quantities of soft shale; and, finally, the feebly coherent fresh-water conglomerates, sandstones and shales of the Orindan (Pliocene) formation of Lawson and Palache (Bull. Dept. Geology, Univ. California, vol. 2, 1902, p. 371). The petroleum deposits are in the shales and sandstones of the Miocene.

"The sandstones below and above the Monterey shale are practically alike, being brown to gray in color, medium grained, and largely quartzitic. The upper sandstone is locally fossiliferous, although the state of preservation of the fossils usually precludes anything but a rough identification. The Monterey shale is fairly hard and is dark colored in fresh exposures, but weathers to a much lighter color. It contains many of the yellow and gray calcareous concretions so characteristic of the Monterey at most places in the Coast Range. The shale is largely organic in origin, foraminifers and diatoms being found in it abundantly. The organic remains in the shale are believed to be the source of the oil. The shale is considerably contorted, especially near the axis of the fold, dips of 42° S., 86° E. and 40° S., 70° E. being recorded within a short distance of each other in the bed of Lauterwasser Creek northeast of the Miner ranch house. At the same locality the shale is exceedingly petroliferous, yielding a very prominent scum of light oil when the rock in the stream bed is disturbed with a pick. The dips in the overlying sandstone are not as easily obtainable as those in the shale, but it is thought that the dip on the northeast flank of the fold grows gradually less toward the northeast.

"*Wells.*—Eight wells have been drilled in the Miner ranch field, none of which have so far been successful. They range in depth from about 570 feet to more than 2,750 feet. All lie on the northeast flank of the Miner ranch anticline, and all start in the sandstone above the Monterey shale, penetrating at first the upper sands and intercalated soft shales, and the deeper ones eventually reaching the Monterey shale. All the wells have shown more or less gas; in fact, the abundance of gas is one of the characteristics of this field. It is said that the gas pressure was responsible for the collapse of the casing in at least two of the wells. One well is said to have encountered a pocket of oil at a depth of about 1,300 feet, which flowed 300 barrels of oil in nine hours. This is the only well in the field that has actually produced, with the exception of the Flood well, 1½ miles to the south, which is reported as having yielded five barrels of 29° oil. The oil and gas apparently occur in pockets or lenses and no well defined oil sand or petroliferous zone has yet been proved to be present."

HUMBOLDT COUNTY.

NOTES ON GEOLOGY AND OIL POSSIBILITIES.

By WALTER STALDER.

The following is a brief description of conditions pertaining to certain areas in Humboldt County, California, in which evidences of petroleum are manifest and in which many attempts have been made to produce oil in commercial quantities. This information was obtained as the result of a number of reconnaissance trips through the district at intervals from 1904 to 1912. The purpose of these trips was first to find out why previous attempts at profitable production had been unsuccessful, and second to search out more ideal localities to test if such exist.

The conclusions reached are that the wells so far drilled have in a way fairly tested the district and that it is not capable of any great commercial production. It may be possible, however, with a comparatively small expenditure and with good management to produce small amounts of oil at a profit and place the county on the list of producers. The idea of any great production is not compatible with geologic conditions as they exist in the field.

Location and Topography.

The area in which oil indications are found may be roughly described as lying between the Pacific Ocean and a line commencing about one mile north of Cape Fortunas passing to the north of Bear River Ridge as far as Scotia, thence along Eel River and the South Fork of Eel River through Garberville and south to the Pacific Ocean, reaching the same near the Mendocino-Humboldt County line. The principal portion of this territory consists of that drained by the Bear and the Mattole rivers and the description will be mainly confined to the same. All of the expanse blocked out does not show oil indications, but at intervals within the lines given beds giving some indications of petroleum are to be found.

The general character of the Bear River and the Mattole districts is that of parallel northwest-southeast trending ridges cut by the narrow stream valleys so characteristic of the Coast Range farther south in California. The ridges, in general, have an elevation of between 2,000 and 3,000 feet, rising in places to peaks of a little greater altitude. As will be noted a little further on, there are one or two exceptions to this statement.

The main ridges involved and gone over by the writer include Bear River Ridge, Cape Ridge, Branstetter Ridge, Rainbow Ridge, Taylor's Peak, Walker Ridge, the Paragon, Buckeye, and Gushaw ridges, Cooskie and King's Peak ranges, Elk Ridge, Wilder Ridge, Moody Ridge, and a smaller unnamed ridge that is herein referred to as Edmonstone Ridge.

Bear River Ridge separates Bear River drainage from that of Eel River on the north. From Bunker Hill, a point situated on the west end of the ridge and about four miles from the Pacific Ocean, this ridge trends in a southeasterly direction with a general elevation of a little over 2,000 feet until it reaches Mt. Pierce, or the Monument, as it is locally known, when it attains an altitude of 3,270 feet. To the west from Bunker Hill toward the ocean the fall is at first precipitous into the headwaters of Oil Creek and then more gradual until the ocean cliffs and terraces are reached. The cliffs are precipitous to an elevation of 200 to 300 feet. Oil Creek drains the Bear River Ridge country on the west and flows directly to the ocean. From Bear River Ridge to Bear River the slopes are comparatively gentle in the lower part of the valley but increase in steepness in proceeding up the river. Near the ocean this ridge is marked by some well defined terraces, particularly to the north of Bear River. Bear River Ridge is flanked on the north by a combination steep and gentle slope topography which Prof. A. C. Lawson (University of California Bull. Dept., Geology, Vol. 1, p. 255) has so aptly described as resembling "a choppy sea of sharp hills and serrated ridges." This continues northward seven miles to the floor of Eel River Valley and from the ocean eastward to and beyond Scotia.

The divide to the south of Bear River is really a series of ridges commencing at the ocean in what is known as Cape Ridge. Branstetter Ridge, which involves two peaks, sometimes called the Twins, rises from Cape Ridge to the south of the headwaters of Singley Creek. Pictoe Hill and Rainbow Ridge are to be found extending to the east of Cape Ridge and attaining altitudes of 3,000 feet and more. These eminences divide the waters of Bear River from those of Singley Creek, Davis Creek and the Mattole River. The slopes from these ridges to the creeks that drain them are as a rule steep.

Taylor's Peak, a 3,410-foot eminence, is nearly surrounded by streams and stands as a "sugar loaf" to the east of Branstetter Ridge, southwest of Rainbow Peak, southeast of Pictoe Hill, and between the north and east branches of the North Fork of the Mattole River.

Walker Ridge, which forms a "U" shaped backbone with Branstetter Ridge, divides the waters of the Mattole and of McNutt Gulch from those of Davis Creek. This ridge rises with considerable prominence to the northwest of Petrolia and dies away near the ocean.

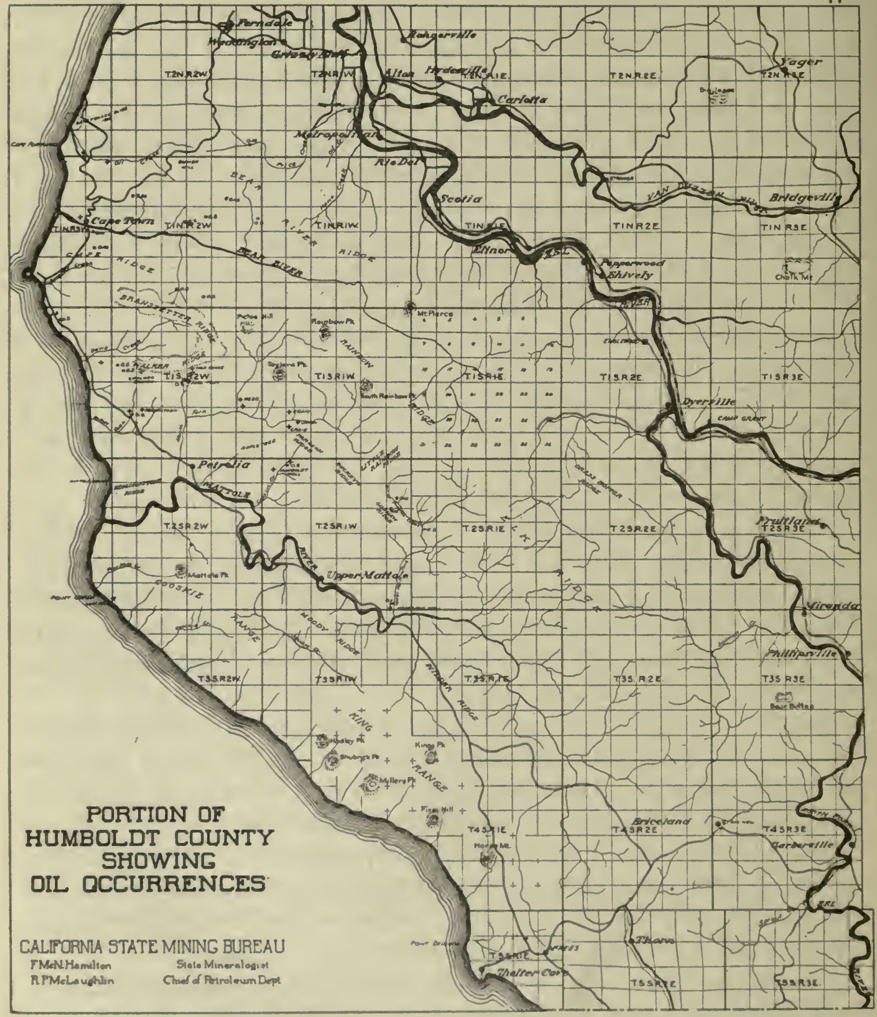
Further east the waters of the Mattole and Bear rivers are separated by a watershed which follows the backbone of Rainbow and of South Rainbow ridges.

Elk Ridge, which is really an eastward extension of Rainbow Ridge, divides the waters of Bull Creek (a tributary of the South Fork of Eel River) from those of the Mattole River.

It is interesting to note that it is possible to pass along the divide to the north of Bear River, around the headwaters of that stream and along any of the ridges or divides so far mentioned without crossing a stream of any kind. The ridges are capped with material which offers the same resistance to erosion.

The Mattole River is separated from the Pacific Ocean on the southwest by Cooskie and King's Peak ranges and their extensions—Horse Mountain and Chemise Mountain. This divide is rather interesting in that it rises very abruptly from the ocean and attains a maximum elevation of 4,265 feet in King's Peak, which is only about four miles from the Pacific Ocean. This divide also marks the northern course of the San Francisco fault rift of 1906. The slopes on either side of King's range are very precipitous and in many places inaccessible. Along Cooskie range the slopes become more gradual. King's range is an exception to the surrounding ridges of the area under discussion in that it attains an altitude of over 4,000 feet.

77


PORTION OF HUMBOLDT COUNTY SHOWING OIL OCCURRENCES

CALIFORNIA STATE MINING BUREAU
F. McN. Hamilton State Mineralogist
R. P. McLaughlin Chief of Petroleum Dept

Moody Ridge, which separates upper Squaw Creek from the Mattole Valley, is really an outlier of King's range and has been developed by faulting, as was first suggested by F. M. Anderson (California State Mining Bureau, Bull. 19, p. 163).

Between Rainbow Ridge and the Mattole River is a lower ridge known on its western end as the Paragon and Apple Tree and on its eastern end as Buckeye and as Gushaw ridges. This ridge is separated from Rainbow Ridge and Taylor's Peak by a stream called Oil Creek and the east branch of the North Fork of the Mattole River. (*Writer's note:* The Oil Creek here mentioned is really the west branch of the Upper North Fork of the Mattole River and should not be confused with that to the north of Bear River or that emptying into Eel River below Rio Dell. This repetition of geographic names is unfortunate, but it is very common throughout the United States. The name "Preston" Creek is offered as a substitute for Oil Creek in this instance.)

Wilder Ridge lies between King's Peak range and the Mattole River, being to the east of Moody Ridge and separated from King's Peak and its eastward extension by the headwaters of Honey Dew Creek and the West Fork of Briceland Creek.

Immediately to the north of the mouth of the Mattole River is a small ridge which has been cut off by faulting before it reaches the town of Petrolia. This ridge has no name as far as could be ascertained. It will be herein referred to as Edmonstone Ridge.

Geology.

The formations involved in this area consist of the (1) Franciscan formation; (2) a basal sandstone series; (3) what is herein given the name of the Rainbow series; (4) the Bear River formation; (5) the Wild Cat series; (6) terrace deposits, dune sands, and river deposits.

(1) *Franciscan series.* The oldest rocks exposed in this general vicinity is that altered and intruded sedimentary series known throughout the Coast Range as the Franciscan. It consists here primarily of altered grayish green sandstone and serpentine. This formation is not very extensive within the area blocked out, being mainly confined to a tongue-like projection which crosses the South Fork of the Eel River from four to nine miles to the north of Garberville and extends just to the west of Bear Buttes. The main Franciscan area of which this tongue-like mass is a part is out of our bounds and has been observed extending from northern Mendocino County, passing immediately to the east of Garberville, again to the east of Eureka and entering the Pacific Ocean immediately to the north of Little River. This Franciscan series bounds on the east a sedimentary area in Humboldt County of which that now under consideration is probably the oldest part in the county.

(2) *Basal sandstone series.* At the base of the beds succeeding the Franciscan formation is a series of rather massive grayish green fine

grained sandstone beds alternating with very minor shale beds and in one or two instances intruded with diorite and with basalt. They contain in places a limestone layer of from three to five feet thick and a coarse conglomerate has also been observed. These beds are to be found to the north of Bear River Ridge in Upper How Creek, in Bear River one half mile to the east of the Johnson ranch house and on eastward at intervals through the Rainbow and South Rainbow ridges, being exposed where deep creeks cut across the same, in the creek to the north of Taylor's Peak, in the first prominent point to the north of Mattole Landing, and to the north of the Mattole River at intervals crossing Conklin Creek in the neighborhood of the Goocher ranch house, where the old Humboldt well was drilled.

(3) *Rainbow series.* This series consists of what are herein given the name of (*a*) Walker Ridge shales and (*b*) Walker Ridge sandstones.

(3*a*) *Walker Ridge shales.* Above the basal sandstone series are to be found bluish to black to gray soft shale beds alternating with fine to medium grained gray to bluish sandstones which vary in thickness from three inches to ten feet. The shale sometimes contains minor bands of limestone—sometimes chert, and again narrow secondary lenses of calcite have been observed in a few localities. The shale which constitutes the bulk of the formation is soft and very easily weathered, giving rise wherever exposed to slides which allow both overlying and included strata to slip, giving false dips to the rocks and causing the sandstones to frequently have a slickensided appearance. The result of this sliding is that sharp and reliable exposures are seldom found in place, either on the lower hill slopes or in the valleys. This shale member is the most important oil bearer in the district. It is to be found on the slopes and slides throughout the Bear River and Mattole valleys. It has a thickness of from 500 feet to probably 1,500 feet. From its exposure on the west end of Walker Ridge it will be called the Walker Ridge shale member.

(3*b*) *Walker Ridge sandstones.* As the Walker Ridge shales ascend they become more arenaceous until they give way to a hard massive sandstone member which is usually found capping the higher ridges. This sandstone member is from 50 to 750 feet thick, of a medium texture, varying in color from green to gray and weathering in many instances to a yellowish hue. The particles making up this sandstone are mostly siliceous and well cemented, forming a resistant material which stands up well under weathering conditions. Bear River Ridge, Rainbow Ridge, Taylor's Peak, Branstetter Ridge, Walker Ridge, Elk Ridge, Gushaw Ridge, King's Peak and Cooskie ranges, and Wilder Ridge have this member present and it may possibly be represented in softer material in what is herein called Edmonstone Ridge.

In neither the Walker Ridge shale or sandstone series has sufficient fossil evidence been found to determine the age of these beds. They are known to be post Franciscan and older than upper Miocene. Other than this no statement can herein be made regarding their age. They resemble in lithologic character no beds found in our southern oil fields.

(4) *Bear River series.* At and near the mouth of Bear River is exposed a series of shales and soft sandstone beds. The shales are of a nodular character, containing a very little interbedded limestone and occasionally glauconite sand. The lower shale member is about 300 feet thick. Above the shales are found arenaceous bands and then yellowish sandstones of medium texture, but poorly cemented and finally conglomeritic sandstones and conglomerate. The whole has a thickness of about 750 feet. This formation extends at intervals up Bear River and at the schoolhouse near the junction of Bear River with its south fork the shale beds become quite fossiliferous. These beds are classed as upper Miocene. Beds partially similar to these lithologically have been observed along the Eel River to the east of Elinor at intervals up the Mattole Valley and near Briceland.

(5) *Wild Cat series.* Bear River Ridge is flanked on the north by a series of soft shales, sandstones and conglomerate beds which were first noted by Prof. A. C. Lawson and to which he gave the name ''Wild Cat series'' (University of California, Bull. Dept. Geology, Vol. 1, pp. 255–263). A section of this series is best observed along the cliffs to the north of Cape Fortunas. The basal members consist of shales which become arenaceous in places, giving way to poorly cemented sandstones and finally to conglomeritic sandstones and conglomerates. A paced section of this formation made along the beach gave 5,270 feet, or approximately one mile, as the thickness of these beds from the earthquake slide north. As this slide covers at least 1,000 feet additional the thickness of these beds may be safely placed at 6,000 plus feet. These beds are not really within the bounds of our area but as they are partially included therein they should at least be described in a general way. These beds dip to the north at angles of from 45 degrees at the mouth of Oil Creek on the coast to from 15 degrees to 18 degrees where the conglomerates pass under Eel River Valley.

(6) *Terrace deposits* of minor importance are to be found on the benches noted at the mouth of Bear River, and at other places higher up, as at Cape Ridge, along the benches in cliffs to the south of Cape Mendocino, on the sides of Davis Creek, but the largest deposits of this kind are to be found to the northwest, north, northeast and east of Petrolia. Here gravels are found in distinct terraces which the hand of man could not have made more perfect.

Dune sands are found principally to the south of Cape Mendocino at intervals to the mouth of the Mattole River.

Neither Bear River nor the Mattole River have wide flood plains, so that the alluvial material deposited in their valleys is not very extensive, being confined to narrow bottom lands.

Structure. To work out the structure of this region is not particularly satisfactory in that the soft Walker Ridge shales have allowed much slipping and sliding. This accompanied by very high tilting and faulting will make much detailed work necessary to give an exact interpretation of structure. For the purpose that the writer went into the region such detailed work was not necessary and the following is his interpretation of the general structure.

Bear River Ridge has the structure of a syncline with the Walker Ridge standstones capping the same. The Walker Ridge shales follow below in a comparatively narrow exposure from the upper part of Bear River Valley northwesterly to Oil Creek, widening in exposure as they approach the ocean. The outcrop of shales follows around Bunker Hill up Oil Creek and is found again on the north flank of Bear River Ridge near the head of Price Creek, along which it follows for some distance before being covered by the overlapping Wild Cat beds.

Branstetter Ridge is of the same general synclinal nature involving the Walker Ridge shales and sandstones. On the north flank of the ridge the beds dip in a southerly direction at very high angles (60° to 80°), and reappear again on the south slope where north dips were recorded.

Taylor's Peak involves the same beds and is of the same synclinal nature as is Rainbow Ridge.

Walker Ridge is also of a synclinal nature involving the same beds. Those dipping into the ridge on its south flank, however, are not so highly tilted, dips from 30° to 45° having been recorded. A fault forms an escarpment on the south of Walker Ridge.

The Paragon and Gushaw ridges represent the south exposures in part of a synclinal fold which is modified by faulting caused by the same fault which cuts Walker Ridge. Walker Ridge sandstones and shales are involved with distinct northerly dips on the south slopes of the ridge.

Wilder Ridge has apparently the same synclinal nature but has not been very thoroughly examined.

King's Peak range involves the same formations and is a fault block in part. This country has not been thoroughly traversed and will require some time to be so examined. For the purpose of the writer's examination, a couple of horseback trips into the area satisfied him sufficiently that the oil possibilities would not warrant a more detailed examination.

Pictoe Hill appears as a distinct fault block, the fault extending to and along the south flank of Rainbow Ridge. In what would be anticlinal folds separating the synclinal ridges, the basal sandstones are usually exposed as is the condition in the central Bear River Valley, to the south of the east end of Walker Ridge and of Taylor's Peak and to the south of Paragon Ridge. No closed anticlines involving the Walker Ridge sandstones and shales (the oil-bearing member) have been found, although that was the primary object of the search.

At the mouth of Bear River the Bear River series is involved in a very sharp synclinal fold with axis immediately south of the river and trending in a general east-west direction.

Edmonstone Ridge to the north of the Mattole River also forms a distinct synclinal ridge with comparatively gentle dips. This ridge is cut off before proceeding very far in an easterly direction and in a way acts as a plug at the mouth of the Mattole Valley around which the Mattole River has worked its way. Well marked terrace structure is developed to the east of this peak in the vicinity of Petrolia, as has been already mentioned. No terrace structure to correspond with the same has been followed on the south flank of Edmonstone Ridge, where it slopes to the Mattole River. The fault rift of 1906 passes to the east of this ridge. All of these facts are suggestive of the isolated position of this ridge being due to faulting.

Oil Indications.

Wherever the Walker Ridge shale member is exposed, search in the vicinity will usually bring forth some evidence of petroleum either in the way of a piece of the freshly fractured included sandstone smelling like a freshly opened kerosene can—a gas seepage sometimes accompanied by clinkers produced by its burning, and again oil seepages. While standing in the wind which blows across these shale areas, particularly near the coast, a distinct odor of petroleum is very frequently noted.

Oil seepages have been noted by the writer on the Nat Hulburt ranch on the south flank of Bear River Ridge, at what was called the Guptill Spring on the Bonanza ranch of Z. Russ & Sons Company, at the junction of the South Fork of Bear River with the west branch of the South Fork, in the creek bed near the head of the east branch of the South Fork of Bear River, in the wagon track at a point on the road about two miles north of Davis Creek, near the mouth of Davis Creek, on the north slope from Walker Ridge, on the D. Zanoni ranch one mile northwest of the Jesse Walker ranch house, at the Osborne spring on the south flank of Walker Ridge, in McNutt gulch about 100 yards north of where the bridge on the county road passes over the same, on the south flank of Buckeye Ridge on the Charles Johnson claim, on the upper North Fork of the Mattole River near where the west branch of the same comes in and at the Emil Etter ranch, on the upper North Fork of the Mattole River. These seepages are small, varying from a mere grease spot on the rocks to one or two quarts per day.

Oil has also been observed in much greater quantity in the 10-inch casing of the abandoned Wild Goose well. In 1905 this well was visited and oil stood in the casing within 90 feet of the surface. Gas was bubbling through the same. On lowering a tin can attached to a cord through the liquid the first water was observed in the can after the oil had been gone through for a distance of 105 feet. The earthquake of 1906 turned this well into an artesian well and when visited in 1907 water was flowing out of the top with an occasional oil globule and some gas.

Gas is quite common throughout the area. To the north of Bear River Ridge on the headwaters of Price Creek gas has been observed bubbling up in the creek. It burned with a luminous flame and smelled of gasoline, as did most of the rocks on the south bank of the creek. On the south flank of Bear River Ridge, one half mile east of the gate to the Mazeppa ranch of the Z. Russ & Sons Company, gas escapes and can be readily lighted. The Frank Peters ranch on Bear River is now supplied with natural gas from one of several seepages, which occur nearby. This gas has been escaping for an untold time and has been used repeatedly by campers in lieu of wood. It smells very strongly like gasoline. The chief spring or seepage, which is now covered by an inverted tank, is within 75 feet of the main wagon road from Capetown to Petrolia. At Briceland, the town is supplied by gas from a well drilled into the Walker Ridge shales some years ago. The flow is not particularly strong, but it was sufficient to supply about four stores and dwellings, including the hotel, at the time of the writer's last visit. Gas is also evident up the west branch of the upper North Fork of the Mattole River and accompanies many of the oil seepages throughout the area.

Character of the Oil.

The character of oil obtained from the former "Wild Goose" well is shown in the following analysis by the writer. The sample was taken five years after the well was abandoned. In so standing the oil may have lost some volatile matter:

Fraction	Quantity per cent	Specific gravity	Gravity Baume
0 degrees to 150 degrees	12	.772	51.5
150 degrees to 200 degrees	25	.796	46.0
200 degrees to 250 degrees	21.5	.826	39.0
250 degrees to 300 degrees	17.9	.855	33.5
300 degrees to 350 degrees	12.4	.878	29.5
350 degrees up	9.6		
Residue and loss	1.6		
Total	100.0		

The specific gravity of the original oil is .839 or 37 degrees Baumé. It has a heat value of 11,419 calories. In color it is amber by transmitted light and olive green and florescent by reflected light. From the heavier fractions paraffine separates out quite readily on freezing. This oil contains 0.099 per cent of sulphur and .17 per cent of nitrogen.

Previous Development.

The following table compiled by R. P. McLaughlin will serve to show what development work has taken place in the past:

Humboldt County Oil and Gas Wells.

Name	Section	Township	Range	Date	Depth	Remarks
Craig	30	1S.	1W.	1902	700	
Craig	30	1S.	1W.	1902	800	
*Union or Mattole Petroleum	30	1S.	1W.	1865	30	
	30	1S.	1W.	1865	35	Gas, little oil.
	30	1S.	1W.	1865	60	
	30	1S.	1W.	1865	64	Little Oil.
	30	1S.	1W.	1865	90	
	30	1S.	1W.	1865	95	Little Oil.
	30	1S.	1W.	1865	1,000	Some gas.
	30	1S.	1W.	1865	1,003	
Paragon	30	1S.	1W.	1866	--------	Dry.
Wild Goose	15	1S.	2W.	1902	1,033	Little oil and gas.
Wild Goose	15	1S.	2W.	1902	700	No oil.
Brown & Knowles	12	1S.	2W.	----	300	No oil.
Henderson	15	1S.	2W.	----	500	Little oil.
McNutt Gulch	30	1S.	2W.	1865	250	Little oil.
Mackintosh	29	1S.	2W.	1902	1,700	Little oil.
Reed	14	1S.	2W.	1902	400	Gas.
Davis	33	(?)1S.	2W.	----	1,400	Little Gas.
Knowlton	26	1S.	2W.	----	--------	Shallow; nothing.
Brown & Knowles	24	(?)1S.	2W.	----	300	Nothing.
	24	(?)1S.	2W.	----	220	Nothing.
North Fork	25	(?)1S.	2W.	----	180	30 barrels.
Kellogg	25	1S.	2W.	----	--------	Dry.
Joel Flat	23	1S.	2W.	1867	230	Little oil.
Davis Creek	13	1S.	3W.	1893	800	Little oil.
Humboldt	6	2S.	1W.	1901	2,000	Trace.
Burrows	5	2S.	1W.	1892	800	Little oil.
Fonner	33	2S.	1W.	1866	300	Little gas.
	28	2S.	1W.	1867	250	Little gas.
	28	2S.	1W.	----	300	Little gas.
Jeffery	4	(?)2S.	2W.	1867	900	Little gas.
Joel Flat	3	1S.	2W.	----	--------	Dry.
	8	2S.	2W.	----	--------	Gas.
Hoagland	2	3S.	1W.	1901	2,100	Little oil.
Briceland	18	4S.	3E.	----	780	Gas piped.
Fortuna	18	1N.	1W.	1864	600	Some gas.
	19	1N.	2W.	1864	200	Nothing.
	21	1N.	2W.	1865	200	Little gas.
Bear River	16	1N.	2W.	----	--------	Shallow; no oil.
Bear River	16	1N.	2W.	----	--------	Shallow; no oil.
Bear River	16	1N.	2W.	----	--------	Shallow; no oil.
Bear River	12	1N.	3W.	----	--------	Shallow; no oil.
Briceland, 5 miles SE. of Garberville	13	1N.	3W.	----	2,100	Granite at 503; spring; gas piped.

*Several hundred barrels produced on Union.

Future Possibilities.

The wells so far drilled in the territory have fairly well tested the possibilities. Those situated on the south flank of Walker Ridge and of Taylor's Peak along the North Fork of the Mattole River have been the most successful in a small way. They produced what oil was obtained from the sands interbedded with the Walker Ridge shales and from the south limb of a synclinal fold near a normal fault.

In handling a problem where oil occurs along synclinal ridges and not sealed in we do not have to search far to find where such a condition has been successfully taken care of in a small way. At Sulphur Mountain in Ventura County the Union Oil Company of California has been producing oil for over twenty years under similar conditions of structure. The production is small but steady. This has been successfully accomplished by tunneling into the ridge and striking an oil-bearing sand down its dip. The oil as it seeps into the tunnel flows out and is collected in suitable tanks. This works continuously and the attendance cost is practically nothing. Near the Osborne spring on Walker Ridge would be a good site for such an operation, and again below the seepage on the D. Zanoni ranch, as also below the seepage on the Hulburt ranch on Bear River Ridge.

Shallow wells have also been developed along the flank of Sulphur Mountain in Ventura County and prospecting to date in Humboldt County would indicate that something of the same nature might be expected here. A number of wells producing but five barrels of oil per week can be made to pay if they are handled properly. It is going to be this small production that will make this part of Humboldt County a producer, if it is ever to be ranked as such. It must be handled by methods in harmony with the results to be obtained. This part of Humboldt County gives no promise of any large production, but until the inexpensive methods of production are tried it can not be classed as an area which is impossible for commercial production.

EEL RIVER VALLEY, HUMBOLDT COUNTY.

GEOLOGY AND OIL POSSIBILITIES.

By A. K. P. Harmon, Jr.

This report presents a brief description of the possibilities of the Eel River Valley from Scotia to Dyerville as an oil field, with a concise statement of the character of the formations involved.

History.

The presence of oil was known in Humboldt County as early as 1860. The region including the southwestern portion of the county in which the older sediments are exposed and, in consequence, that which shows the greatest evidence of petroleum, comprises T. 1 N., Rs. 1, 2, 3 W., T. 1 S., Rs. 1, 2, 3 W., T. 2 S., Rs. 1, 2, 3 W., T. 3 S., R. 1 W., T. 1 S., R. 1 E., T. 2 S., R. 2 E., Humboldt base and meridian, in all about 432 square miles. During the periods of greatest activity, which occurred in 1860, 1892 and 1900, several wells were drilled, among which were the Craig well in section 30, T. 1 S., R. 1 W.; Humboldt Oil Company in section 6, T. 2 S., R. 1 W.; Wild Goose in section 15, T. 1 S., R. 2 W., and Baker & Hamilton well in section 12, T. 3 S., R. 1 W. H. B. and M. None of the above mentioned, or any other well drilled in the territory proved the presence of oil in commercial quantities. Many of them encountered oil in small amounts and several struck considerable gas, which in some cases is used at the present time for lighting and heating purposes. The oil obtained from these wells varied from 33° to 40° Baumé, was rich in naphtha and lubricating oils and after final distillation left a residue of the best grade of paraffine.

Location and Topography.

The territory under discussion comprises all of T. 1 N., R. 1 E., T. 1 S., R. 2 E., T. 1 N., R. 2 E., the southern part of T. 2 N., R. 1 E., and the northern part of T. 1 S., R. 1 E., Humboldt base and meridian.

The Eel River Valley, between Scotia and Dyerville, is a depression caused largely by the erosion of the softer beds which flank the east side of Bear River Ridge, of which Mt. Pierce is the highest point, attaining an elevation of 3,270 feet. This ridge trends in a northwest and southeast direction, fairly uniform and unbroken along the western end, but cut in the eastern end by the headwaters of Bear River, Bull Creek and the main Eel River, the last mentioned stream cutting through the entire ridge almost at right angles to the trend. To the east of Eel River the projection of this ridge is flanked on the north by Larabee Creek, and somewhat the same conditions exist here as on the main Eel River to the west.

Geology.

The formations of the Eel River Valley include the Pliocene beds commonly known as the Wild Cat series; a nodular contorted shale which is either lower Miocene or Eocene; and a great thickness of hard siliceous sandstone and dark brown, thin bedded, earthy shales probably of Cretaceous age.

Cretaceous (?).

The Cretaceous (?) series, which is the oldest formation occurring in the territory under discussion, is hard, medium grained siliceous sandstone containing a large amount of biotite mica. Aside from its resistant features the presence of biotite serves admirably to distinguish it in the field. Bear River Ridge along its entire length, the eastern portion of the ridge north of the Eel River and the ridge south of Larabee Creek are all composed of this material. It can be traced to the west for many miles, composing the tops of the highest ridges. Although the slopes in many places are quite steep, the tops of the hills are gently rounded. It is very badly broken up, but the fracturing is more or less conchoidal with no apparent system of cleavage.

Miocene.

The shale which has been designated as Miocene is of a soft bluish gray color, grading into brown near the contact with the Cretaceous (?) which underlays it. The main body of it shows no distinct bedding, but is composed of large irregular nodules, and is very badly contorted.

Near the contact with the Cretaceous (?), however, there is shown a distinct bedding. In only one locality were fossil specimens obtained, that of *Pecten peckami* Gabb being the most common, which alone serves tentatively to correlate this formation with the lower Miocene of the Bear River region near Capetown. In the vicinity of Briceland in section 18, township 4 south, range 3 east, there occurs a shale having the same general characteristics as the above described, but aside from numerous imperfect casts of *Phacoides richthofeni* Gabb, no other fossil specimens were obtained. That portion which is exposed along the railroad east of Elinor gives a distinct odor of petroleum, so noticeable at times that it can be detected while passing on foot. Aside from this there is no further surface evidence of petroleum in this vicinity.

Pliocene.

The Pliocene formation, commonly known as the Wild Cat series, consists of about 5,000 feet of shale, sandstone and conglomerate, the best exposure of which occurs just northwest of Scotia. Photo 2 shows the entire series from the uppermost yellow sandstone or conglomerate on the left to the point where it grades into the Miocene on the right.

Of this there is exposed near the base 670 feet of a soft bluish gray nodular shale which corresponds somewhat to the shale previously described as Miocene, but as the total thickness is not exposed nothing definite regarding this can be stated at present. The dip is 40° north strike N. 80° E. Overlying this is 1,000 feet of tough blue argillaceous sandstone, dipping at about the same angle, through which the gradual change from shale to sandstone can be readily traced. The massive appearance of this sandstone can be seen in Photo 3.

As the sandstone grades into the shale the formation becomes softer, thus leaving the harder overlying portions of the sandstone standing alone as is shown in Photo 4. The contact between shale and sandstone is shown in the center of the photograph. To the left of the picture is shown the condition where the sandstone not having sufficient support has been broken off and allowed to settle into the softer shale. On the right can be seen the dense growth which covers most of the shale area. Above this occurs 1,500 feet of coarse brownish yellow sandstone, the massive appearance of which is shown in Photo 5, and 150 feet of firmly cemented conglomerate. Overlying this is exposed 2,000 feet of soft yellow sandstone which dips about 40° to the north and strikes about east and west. At this point it plunges into the inaccessible country south of the Van Duzen River and could not be followed further. With few minor differences of thickness this same section occurs northeast of Shively and in the head of Stitz Creek except where it is cut off by faulting.

The series is fossiliferous at several horizons, the lower portions yielding the largest number of specimens. There has been collected and identified about fifty species, many of which are new. Among those encountered were:

Pecten caurinus Gould.
Paphia staleyi Gabb.
Polinices inezana Conrad.
Chrysodomus sp.?
Scutella interlineata Stimpson.
Cardium meekianum Gabb.
Phacoides acutilineatus Conrad.
Marcia oregonensis Conrad.
Natica clausa Brod. & Sow.
Cardium coosense Dall.
Chrysodomus tabulatus Baird.
Spisula albaria Conrad.

Structure.

The structure of the Eel River Valley, as far east as Bryans, is that of an eroded monocline contracted in the western part, and expanded in the eastern part where the river turns at a sharp angle to the south and cuts through the entire series exposing the same conditions as exist at Scotia.

At this point Larabee Creek flows west and joins the main Eel River and the monoclinal structure continues along parallel to this stream. Bear River Ridge and its eastern extension to the south of Larabee Creek is composed of Cretaceous sandstone which is the hardest and most resistant of any formation occurring in this vicinity, and consequently the river during its period of erosion worked downward along the northern slope of the ridge, wearing away the softer Pliocene beds which rest against it. This was facilitated by the occurrence of a fault block which, in its upward movement, brought to the surface the lower Miocene or Eocene shale, which is very soft and easily worn away. As this and the lower sandstone and shale of the Pliocene are softer than the middle members of the overlying Wild Cat series, erosion took place much more rapidly when this horizon was reached, leaving the harder strata of the younger formations standing as steep precipitous bluffs.

There are two distinct fault lines trending east and west which mark the north and south boundaries of an immense block which has been forced up through the Pliocene beds, exposing on its northern edge the Cretaceous sandstone. The territory through which both fault lines pass is visible from a point north of Pepperwood. The south line passes down a ridge at the extreme left and turns west along the bottom of the valley, while the north line passes through the highest point of a ridge on the right, the two lines converging both in an east and west direction from this point. In the middle distance a large body of lower Miocene or Eocene shale is visible. In order to bring this block to the surface the upward movement must have been fully 3,000 feet; since the present crest of the ridge north of Shively, which is composed of the Cretaceous portion of the block, is at practically the same elevation as the highest point of the Pliocene beds as they now exist. At the point where the south line of the fault now crosses the river the upward movement of the block turned the ends of the Pliocene beds up until they are dipping at an angle of 20° to the south. This condition would, to a casual observer, suggest the presence of an anticline, but the same beds as they occur about a mile northeast of Shively are found dipping normally to the north at an angle of about 35°.

There is a possibility of minor faults existing which were concealed beneath the dense growth of timber and vegetation, but none of which were of such magnitude as the one previously described.

Conclusion.

The oil of this field is supposed to occur in the lower Cretaceous beds. If there is no impervious stratum overlying them it will naturally find its way to the surface and be dissipated. This has no doubt been the case in the locality east of Elinor, as the shale which has been described as Miocene gives strong evidence of having been at one time impregnated with petroleum. The sandstone which has been described as Cretaceous would not serve as an impervious stratum and the possibility of an older underlying formation acting in the capacity of a reservoir could only be ascertained after a careful study of a very large area to the southwest of the territory already described. However, if such were the case it would be at a depth which, combined with the possibility of encountering oil in commercial quantities is reduced prohibitive.

Therefore, the territory described must be classed as one in which the possibility of encountering oil in commercial quantities is reduced to a minimum.

IMPERIAL COUNTY.

The following quotation, as to oil in Imperial County, is from recent work of Dr. F. J. H. Merrill, of the State Mining Bureau:

"This important fuel has been sought by boring on the west side of Imperial Valley, but without result. While Miocene beds are present in this valley, it would appear that the conditions under which they were deposited were not specially favorable to oil formation.

"The principal well was the Yuha, Sec. 32, T. 16 S., R. 11 E., drilled by the Yuha Oil Company, Chas. Swallow, of San Diego, secretary-treasurer. It reached a depth of 1,363 feet without result. Another well was the Mesquite, about 850 feet deep, in Sec. 27, T. 12 S., R. 10 E. This brought a supply of flowing water.

"The Barrett well, drilled near Carrizo Creek to a depth of 1,100 feet, was also unsuccessful."

Mr. R. N. Ferguson has also examined this region but reports finding no oil indications.

LAKE COUNTY.

Gas and oil in Lake and Napa counties are reported by W. W. Bradley, as follows:

Natural Gas.

"At Kelseyville is a gas well which was used for a time for illuminating purposes, but the gas was not dried and it is stated that acid in the moisture corroded the supply pipes. The gas flow was struck at a depth of 158 feet. The buildings connected with it were burned and have not been rebuilt. The gas is also said to have been tried in a gas engine. It is not utilized at present and the well is capped."

Petroleum.

"There are oil seepages reported on the east, southeast and northeast of Morgan Valley, in the southeastern part of Lake County. The valley has flat-lying sandstone and it is thought they 'may have oil underneath.' Some of the seepages have been prospected and a small amount of high grade oil (paraffine base) said to have been obtained. Some light oil was found a few miles southeast of here, in the Knoxville quicksilver mine (Napa County), on the 400-foot level at the sandstone contact, and was used as a lubricant around the mine machinery."

NAPA COUNTY.

Petroleum.

"Petroleum and gas have been found in small quantities in sandstone west of Napa and Yountville, but not developed.

"The East Napa Mining Company drilled to a depth of between 1,000 and 1,200 feet at the southern edge of Napa City, and at that depth claim to have found 'oil indications,' though they did not expect oil until a depth of 2,500 feet was reached. Work stopped for lack of funds. A. Zeller owns the property."

MOJAVE DESERT REGION.

(San Bernardino, Kern, and Inyo Counties.)

The Mojave Desert has not been entirely examined and mapped in detail. It is an uninhabited region, and hence reports are frequently circulated as to its oil possibilities. All the information thus far gathered is of a negative character and does not justify one in expecting oil fields to be developed.

An examination and report made by R. W. Pack (Bulletin 541, U. S. Geol. Survey) in 1912 sets forth the geologic conditions in the region. His conclusion is, in part, as follows:

"The northern part of the Mojave Desert between Barstow and the town of Mojave offers practically no promise of becoming a productive oil field, and further drilling will prove but a waste of money. The principal reasons for believing that this land will not prove productive are (1) the lack of strata from which it would seem reasonable to believe that oil might have been formed, especially the lack of thick masses of organic material (diatomaceous and foraminiferal shale) such as those which occur in or near all the oil fields in the southern half of California and in which the oil is believed to have originated; (2) the lack of structural features favorable for the collection of petroleum even if it existed disseminated through the strata.

"The pre-Tertiary rocks can not reasonably be regarded as a source of petroleum. Only a small portion of these rocks are of sedimentary origin, and they are so metamorphosed that even had oil once existed in them it is hardly conceivable that they should still contain it. The granitic rocks in the complex are if possible an even less likely source of petroleum, as their texture is so dense that they would offer practically no reservoir in which oil might collect if it existed in the near-by rocks. Oil has been found in rocks lithologically similar to some of the pre-Tertiary rocks of the Mojave Desert at only a single locality in California. This occurrence, at Placerita Canyon, about 20 miles north of Los Angeles, has been described by Eldridge.* The oil at this place occurs in fractured schists which rest upon the granite of the San Gabriel Mountains. The most logical explanation for the presence of the oil here is that it has migrated from early Tertiary organic shales which may have at one time rested upon the metamorphic rocks and which may now occur in the vicinity beneath the unconformably overlying late Tertiary beds. In the Santa Clara River Valley, a few miles west of Placerita Canyon, the early Tertiary strata and the beds in contact with them are filled with oil. As organic materials similar to those in the Santa Clara River Valley are unknown in the Barstow-Kramer Region, it can not be expected that a similar accumulation of oil will be found in the metamorphic rocks in this region.

"The Recent coarse gravel, sand, and clay which form the filling in the topographic basins and which in places extend as a veneer over the lower hills are equally as unlikely a source of petroleum as the pre-Tertiary complex. They are composed almost or quite completely of fragments derived from the older rocks in this or in adjacent regions, and it is not reasonable to believe that these masses of rock fragments would be more likely to produce petroleum than the same rocks in place. The Tertiary volcanic rocks are likewise not to be considered as a source of petroleum, for much the same reasons as apply to the granitic rocks in the pre-Tertiary complex.

"It remains then but to consider the Tertiary sedimentary rocks. The coarse-grained Tertiary beds are formed of fragments of various types of granitic, volcanic, and metamorphic rocks and are evidently no more probable a source of petroleum than are the Recent beds of sand and gravel. On the other hand, to casual observation the fine-grained

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*The Santa Clara Valley, Puente Hills, and Los Angeles Oil Districts, Southern California; U. S. Geol. Survey Bull. 309, pp. 100–101, 1907.

Tertiary rocks of the Barstow-Kramer Region appear to be similar to the Tertiary rocks in many of the oil fields of this state, and it is not so very surprising that in this region they have been regarded as a possible source of oil. A careful examination of them shows, however, that they are really very different from the Tertiary shales in the productive oil fields, and in place of being composed very largely of the remains of organisms they are formed almost wholly either of fine volcanic ash or of detrital material derived from rocks of various types. They thus resemble the coarse-grained beds in the same region, differing from those beds mainly in the size of the particles they contain, and are not to be compared with the masses of organic material in the large productive oil fields of California. The only indications of organic matter seen in these beds were small particles of carbonized terrestrial vegetation scattered through some of the clayey and finer sandy beds, but the total amount of organic matter is entirely too small to be considered as a possible source of more than the merest traces of oil.

''It is, of course, possible that in the broad, level desert areas rocks of different types from any exposed in the hills may lie buried beneath the desert gravel. It is also possible that such rocks, if they occur, are like those in the Tertiary formations in the San Joaquin Valley on the opposite side of the Tehachapi Mountains. There is, however, nothing in the geology of this region, or, so far as known, in that of the desert as a whole, to support such a hypothesis.

''No surface indication of petroleum was seen anywhere in the region. It is commonly rumored that a seep occurs in the Tertiary rocks northwest of Black Mountain, but a careful search failed to reveal it nor did persistent questioning discover any one who could describe its location. The structure of the Tertiary rocks is complex. In many places they are tilted to high angles and intricately faulted, and if oil occurs in them it is surprising that it does not at some place show at the surface.

''Even if oil was originally distributed in minute quantities through the rocks, the structure is not such that it would have tended to collect or trap the oil. Irregular and faulted folds occur in at least three places northwest of Barstow—the Barstow syncline in T. 11 N., R. 2 W., a small anticline just north of the Giroux well in T. 32 S., R. 44 E., and an irregular fold or folds in T. 31 S., R. 44 E. It is generally reported that a well-marked anticline passes through the hills north of Barstow. Indeed, it is believed by some that such a fold extends along the north side of the desert from Tehachapi Pass nearly to Barstow. This idea is erroneous, for the only folds here are small, discontinuous, and much faulted. Faults, not folds, dominate the structure. Thus the structure is much more favorable for the escape of any oil that might possibly have been found here than it is for its concentration in appreciable quantities."

The unsuccessful wells mentioned in the above report are:

Kramer Consolidated	Sec. 11,	T. 10 N.,	R. 5 W.,	3,000 feet deep
Chicago	Sec. 35,	T. 11 N.,	R. 1 W.,	2,000 feet deep
Giroux	Sec. 17,	T. 32 S.,	R. 44 E.,	400 feet deep
Mojave	Sec. 14,	T. 11 N.,	R. 12 W.,	1,100 feet deep

The author, several years ago, made a hasty examination of the region north of Mojave as far as the Inyo County line and noted nothing which would justify a detailed examination in search of oil. A well was then drilling near the railroad some fifteen or twenty miles south of the Inyo County line. Gas had been reported in water wells drilled near the town of Inyokern, but one of the drillers, who was familiar with oil field work, reported that he had seen no indications of oil. Igneous and metamorphic rocks in that vicinity underlie the alluvium at no very great depth.

MONO COUNTY.

Attempts have been made to develop oil near Mono Lake and a brief statement, based upon examinations by the author, of the very scant possibilities may be useful. Surrounding the lake are sedimentary deposits containing marl, clay and diatoms, volcanic ash and gravel. Israel C. Russell reports* a measured thickness of 200 feet and states that the total must be very much greater. This deposit was laid down during Quarternary time when the lake was much larger than at present. There are no other unaltered sediments known. The lake deposits rest upon granite, metamorphics and glacial drift and are intruded or overflowed by recent basic igneous rocks.

The only reported indications of oil is a spring near the eastern shore of Paoha Island. Russell mentions this spring and the fact that it had an odor of petroleum. However, he gives the temperature of the water and its analysis but makes no further mention of the presence of oil. Several experienced oil men have stated that they collected oil on the surface of the water.

During 1908 there were two wells drilled. One near Dechambau's Ranch, on the northern shore of the lake is about 900 feet deep and hot water flows over the casing. The other well, near the southwestern shore of Paoha Island, was drilled to 2,010 feet all in blue shale except between 1,700 and 1,800 feet where pink sand gave a strong flow of hot water which rose over the casing.

There is no reason to suppose that other drilling would be successful.

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*U. S. Geol. Surv., 8th Annual Report, Part I, pp. 261-394.

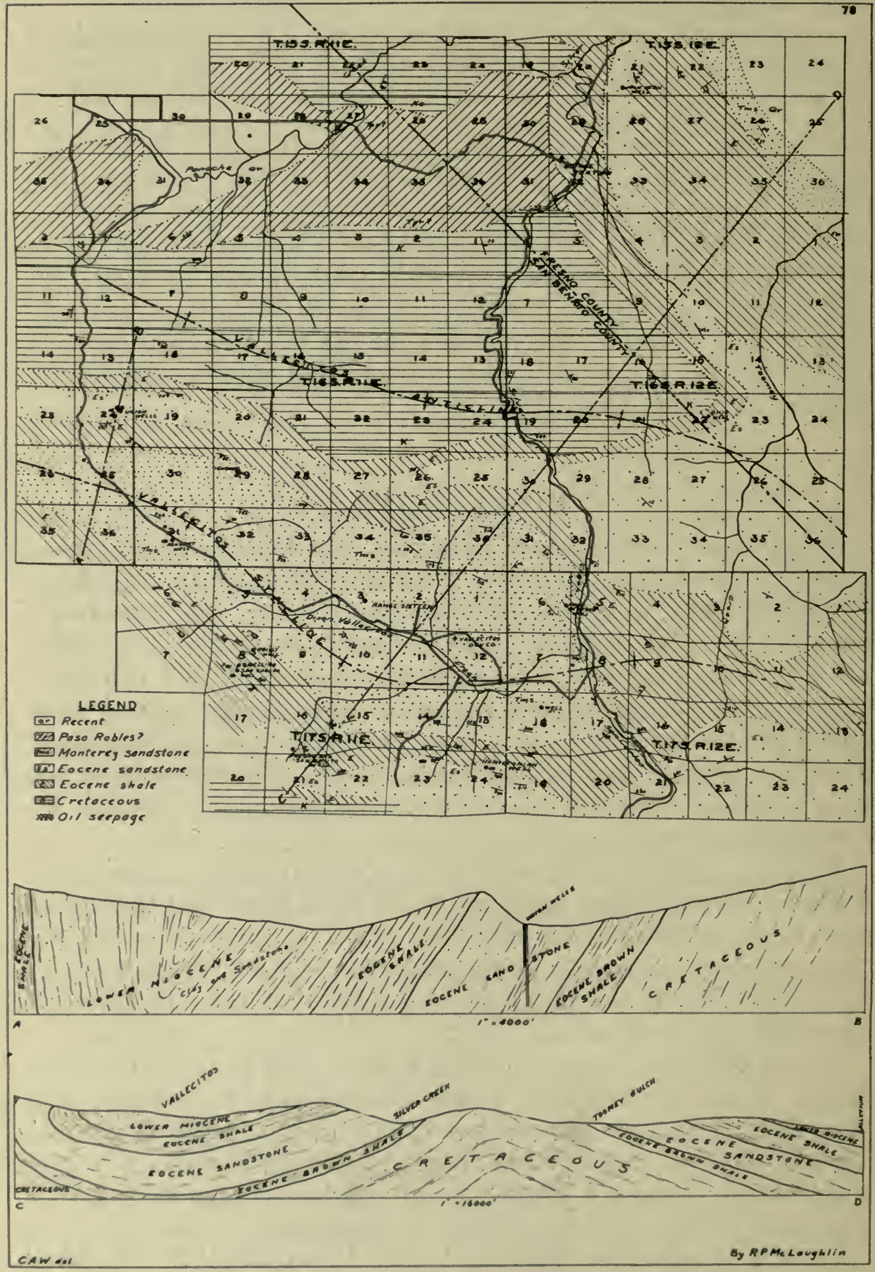

Fig. 78. Geologic map of Vallecitos District.

SAN JOAQUIN VALLEY.

WEST SIDE, NORTH OF COALINGA.

Northward from Coalinga, along the base of the Temblor Range, all the Coalinga formations continue nearly to the boundary of Fresno County; thence northward to the San Joaquin County region, little aside from Cretaceous and Franciscan rocks are exposed.

Throughout most of the region the structure is monoclinal, the beds dipping away toward the valley. An exception occurs in the Vallecitos locality, in San Benito County, where several folds carry the Tertiary beds well back into the hills.

Detailed examination, by the author, has revealed the presence of oil only in the folded region near Vallecitos, the remainder of the country from Coalinga to San Joaquin County being apparently barren.

The Vallecitos District has been pretty thoroughly prospected without economic results, although a number of wells have struck small quantities of light oil.

The accompanying map (Fig. 78) and cross-sections with the list of wells show more clearly than would a description the slight economic possibilities. Oil is probably present at the base and also near the top of the Eocene formation but large production is not to be expected.

For a more complete descripton of the geology the reader is referred to the works of F. M. Anderson (Proceedings California Academy of Sciences, 3d Series, Vol. 2, 1905) and Robert Anderson (U. S. Geological Survey, Bulletin 431).

Wells in Vallecitos.

Union	Sec. 24, T. 16 S., R. 10 E.,	1,000 to 1,500 feet; some oil.
New Bedford	Sec. 6, T. 17 S., R. 12 E.,	1,700 feet; some oil.
Range Sixteen	Sec. 3, T. 17 S., R. 17 E.,	Drilling.
Hamiltonian	Sec. 24, T. 17 S., R. 11 E.,	1,500 feet; no oil.
Reilly	Sec. 8, T. 17 S., R. 11 E.,	1,500 feet; no oil.
Ashurst	Sec. 18, T. 17 S., R. 12 E.,	1,050 feet; gas.
Ashurst	Sec. 31, T. 16 S., R. 11 E.,	Several shallow wells.
San Carlos	Sec. 8, T. 17 S., R. 11 E.,	200 feet; few barrels oil.
Ohio	Sec. 22, T. 16 S., R. 12 E.,	1,500 feet; no oil.
Ohio	Sec. 32, T. 15 S., R. 12 E.,	1,600 feet; no oil.
John Kern	Sec. 21, T. 15 S., R. 12 E.,	3,000 feet; drilling.
Fresno and San Benito	Sec. 16, T. 17 S., R. 11 E.,	216 feet; some oil.
Snelling	Sec. 8, T. 17 S., R. 11 E.,	1,000 feet; showing of oil.
Vallecitos Dev.	Sec. 12, T. 17 S., R. 11 E.,	2,250 feet; showing at 1,750′, Eocene at 1,950′.

SOUTHERN END AND EASTERN BORDER.

The geology of these regions has been very briefly described by Robert Anderson (Bulletin 471, U. S. Geological Survey) and by F. M. Anderson (Proceedings of the California Academy of Sciences, 4th Series, Vol. 3) and the following description is summarized from those publications. Some prospect wells have been drilled since the information was gathered for the above mentioned publications, but no oil produced. It is not probable that a continuous productive area will be developed along the base of the hills from Sunset to Kern River, although there are some promising localities.

Igneous and metamorphic rocks compose the core of the mountain ranges south and east of the San Joaquin Valley, coming down close to the floor of the valley.

Along the south end of the valley is a strip of Eocene sedimentary formation lying against the igneous rock and surmounted by later Tertiary sediments. The structure is not regular, beds being upturned and folded similar to those in the West Side oil fields.

Along the east side of the valley the later sediments lie directly on the igneous rocks. In general the structure is simple, the sediments dipping gently to the west, away from the mountains. A notable fact in both regions is the absence of Cretaceous sediments.

For this region the map of California accompanying this publication (see Fig. 1) shows the approximate position of the boundary of the igneous area, which is shown as impossible oil land.

Various geological accounts and observations support the opinion that conditions are somewhat similar along the entire east side of the San Joaquin Valley. The gently dipping sedimentary formations, without known oil seepages or outcrops, lying directly on the igneous and metamorphic rocks, make it highly improbable that productive fields will be developed along the eastern border of the valley for any great distance north of the Kern River Field.

Areas holding some promise, according to Robert Anderson, are located as follows:

1. Extension of Sunset Field into western portion of T. 11 N., R 22 W. (see our description of Sunset Field, page 258.)
2. Region near anticline in sections 27, 28 and 35, T. 11 N., R. 23 W.
3. Southern portion of T. 11 N., R. 21 W., some very slight possibilities.
4. Wheeler Ridge, T. 11 N., R. 20 W., is anticlinal in structure, the axis extending from the center of section 30 through the northern part of section 28 and thence into section 36. There is about 3,000 feet of sedimentary formation similar to that which is productive in the Midway-Sunset Field. Oil occurs as a seepage near the center of section 20, about 1,000 feet above the base of the formation. The most promising area is along the anticline.
5. Tejon Hills region (T. 11 N., R. 18 W. and T. 32 S., R. 29 and 30 E.) offers some slight inducement on account of its anticlinal structure and age of formation, but no outcrop of oil sand is known and deep drilling would be necessary.

SAN DIEGO COUNTY.

The following description is by Dr. Frederick J. H. Merrill of the State Mining Bureau:

"Petroleum of commercial interest has not yet been discovered in this county, although several wells have been and are being drilled, and the operators of these seem quite hopeful of success. In several wells small amounts of gas have been encountered and occasional layers of sandy material, with suggestions of oil, have raised the hopes of the driller, but nowhere has oil been found in measurable quantity.

"It is of interest to note that the middle Miocene beds which are the chief reservoirs of oil in the San Joaquin Valley and in Orange County, have not been identified in the county of San Diego, and the deepest wells in the latter have passed through all the Tertiary beds and the Cretaceous strata and have penetrated a black shale, sometimes calcareous, which is probably of Jurassic age. It is evident, therefore, that, if oil be found, it must occur in beds of different geologic horizon from those constituting the oil reservoirs to the northward (see Ralph Arnold, Trans. Am. Inst. Min. Eng., 1914, Bul. 87, p. 405). It would, perhaps, be unwise to say that it is impossible for oil in commercial quantities to be found in other horizons in southern California, but, thus far, we have no information that will justify the expectation that in this region it can be found in older strata than those yielding oil farther north.

"The chief encouragement to drill for oil in western San Diego County is stated to be the frequent occurrence, on the beaches, of masses of asphaltic residue or brea. The assumption is that this material has come from submarine seepages, and from this idea has sprung the hope that by drilling near the coast it might be possible to reach oil sands from which the inferential seepages may have come. In order to determine what evidence of seepage there might be in the waters near the San Diego coast line, a letter was addressed to Dr. Wm. E. Ritter, Director of the Biological Station near La Jolla, asking whether he knew of any submarine seepages. His reply is given herewith:

'THE SCRIPPS INSTITUTION FOR BIOLOGICAL RESEARCH
OF THE
UNIVERSITY OF CALIFORNIA

La Jolla, California, November 18, 1913.

Mr. F. J. H. Merrill, Oceanside, California.

Dear Sir: Replying to your letter of inquiry about petroleum in the ocean in this vicinity, I would say that we have seen no signs of it south of Redondo. It may be further stated, that our explorations of the sea over most of the continental shelf in this locality have been so extensive that, did outflows comparable with those in the Santa Barbara channel exist here, they could hardly have escaped our notice.

Small fragments of asphaltum do occur, here and there, on shore rocks in many places, but I have always supposed they were brought from long distances—probably from the north.

Yours very truly, Wm. E. Ritter.'

''In conclusion it may be said that while the search for petroleum in this region, by persons with capital to spare for the investigation, is most laudable and evinces in a high degree the existence of a most cordial public spirit, it is not a matter to be undertaken by persons of limited means. As '20 swallows do not make a summer,' so a few bottles, or even buckets, of oil do not make a commercial oil field. The discovery here of a substantial oil field would be of incalculable value, but can not with certainty be anticipated.''

SANTA CLARA AND SAN MATEO COUNTIES.

The geology of San Mateo and Santa Clara counties is complex and has been partly described and mapped by the U. S. Geological Survey (Santa Cruz Folio, No. 163) from which the following quotation is taken:

''Wells have been bored for oil at various places in the Santa Cruz quadrangle, but petroleum has been found in commercial quantities only in a limited area southeast of Purissima. Here small quantities of a light oil of excellent quality are obtained from sandstone beds believed to be intercalated with the Monterey shale a short distance below the base of the Purissima formation. Oil wells bored along the coast west of Santa Cruz, to penetrate at depths the strata which bear bituminous rock at their outcrops, failed to develop any commercial supply of oil. Wells have also penetrated the Purissima and Monterey strata a mile east of the town of Ben Lomond, and also the Monterey beds on Oil Creek, almost at the center of the quadrangle, but always without satisfactory results.

''Apparently the most promising locality for prospecting for oil is that along the coast west and southwest from the outcropping bituminous rock beds, since those beds pass down under overlying shale in that region. Wells drilled here, however, failed to find oil, and it is supposed that the oil which must formerly have existed in the sandstones of the region has been drained off through large fractures which extended from the surface of the shale down to the underlying sandstone. Many sandstone dikes, some of them large size, occur along the coast in this region. These were formed from the underlying oil-bearing sandstones, and the larger ones probably represent the channels through which the oil from the underlying strata escaped.''

Oil in the Vicinity of Los Gatos.

Moody's Gulch. Some of the earliest oil prospecting in California took place in Moody's Gulch and old reports (from which our data on these wells is taken), reflect the hopes of the operators.

Moody's Gulch is in a westerly branch of Los Gatos Creek, about two miles south of Alma. The gulch may be entered from the main county road to Santa Cruz after crossing a bridge near the county water tank.

The geologic formations of Moody's Gulch consist of Monterey shale overlying Vaqueros sandstone which dips S. 40° E. 55°. A fault with a direction of N. 60° W. crosses the gulch close to the northwest corner of Sec. 17, T. 9 S., R. 1 W., M. D. M. This fault has brought the Vaqueros sandstone on the northeast side into contact with Monterey shale on the southwest side. The oil is thought to be obtained from the sandstone of the Monterey series.

Logs of eight of the wells drilled show that four sands were found. The first of these, a 20- to 30-foot sand, ranged from 260 to 400 feet deep; the second, a 20- to 50-foot sand, ranged from 630 to 800 feet deep; the third, a 20-foot sand, ranged from 880 to 980 feet deep; and the fourth sand, consisting of one or more 6- to 12-foot beds, ranged from 1,040 to 1,200 feet deep. The oil was light, being about 40° Baumé.

In the region about the wells on the northeast side of the fault, the formations dip steeply to the southeast and ''Moody No. 12,'' the last well drilled, is on the fault. Of the 14 wells said to have been drilled in the gulch, all have been plugged save Logan No. 1 and Logan No. 2, which are just northeast of the fault.

Logan No. 1 is a 12-inch hole, 1,100 feet deep. It was drilled in 1880 and struck oil sands at 280, 650, 885 and 950 feet. Fifteen barrels of oil per day are said to have been pumped when the well came in.

Logan No. 2 is 1,250 feet deep and struck oil at 1,175 feet. It is said that it will pump ten barrels of 40° Baumé oil per day at the present time.

No operations have been carried on in the gulch for two years. The wells were drilled by old methods and the water was not shut off.

It is possible that consideraable oil of good quality may yet be obtained from the region, but a thorough geological examination should precede any drilling operations in order that wells may be located with proper relation to the fault.

Oil Prospects Northeast of Los Gatos.

The Santa Clara Valley region east of Los Gatos is covered with alluvial gravel, sand and soil so that the underlying formations are completely concealed. From wells drilled in the region it is evident that this land is underlain by rocks of the Monterey series which carry some oil.

Drilling for oil has been carried on near the reservoir of the San Jose Water Company, on the San Jose road two miles northeast of Los Gatos. Oil indications were first noticed on the ranch of Mr. R. C. McPherson in an 85-foot dug well.

Four wells have been drilled in the locality. At two of these the rigs are still standing but no operations are at present being carried on. In a 1,600-foot well back of the barn on the property of Mrs. H. H. Main, gas may be seen bubbling through oil which fills the casing. Some oil is said to have been bailed from this well for use as fuel by the owners. A well on the south side of San Jose road is said to have been drilled 2,530 feet deep, and to have pierced three oil strata.

Sargent Ranch Oil Field.

The Sargent Ranch Field is in Santa Clara County, T. 11 S., R. 3 and 4 E., near the Southern Pacific Railroad.

The geological formations exposed are Franciscan (metamorphic), Monterey (diatomaceous shale) and Etchegoin (sandstone and clay). The Miocene formation dips south and east as it swings around in a broad crescent. Oil is found at the base of the Miocene and at several seepages or brea deposits so situated as to suggest faulting. For another description and map of the district the reader is referred to the work of W. F. Jones, Geological Department, University of California, Vol. 6, No. 3, 1911.

Some drilling was done as early as 1886. Several concerns have drilled wells and some oil has been piped to Chittenden station, where it is shipped by rail. Statistics for the county indicate that several hundred thousand barrels have been produced. The gravity of the oil is from 18° to 19° Baumé.

The most successful development has been by the Watsonville Oil Company, which has five or six wells ranging in depth from 900 to 2,000 feet and which are said to have each produced from 15 to 200 barrels per day. Five of these wells are at present being pumped part of the time.

There are several abandoned wells about a quarter of a mile west of Sargent Station, which encountered some oil. One was drilled about 1,700 feet by the Three Counties Oil Company.

There is a probability that the field could be extended a short distance south and east from the wells of the Watsonville Oil Company with similar economic results.

The surrounding territory to the west and north is largely composed of metamorphic rocks. Some considerable sediments exist towards the southeast. Any further development in the region should be attempted only after a thorough geologic examination.

Santa Clara County.

Oil production and price.

Year	Barrels	Amount
1894	3,500	$2 43
1895	4,000	2 50
1896	900	1 27
1897	4,000	2 50
1898	3,000	2 00
1899	1,500	2 00
1903	4,695	85
1904	42,000	33
1905	41,000	34
1906	7,000	40
1907	22,100	25
1908	35,400	50
1909	63,780	1 22
1910	36,660	1 00
1911	12,828	67
1912	14,092	59

San Mateo County.

Year	Barrels	Amount
1896	1,000	$1 25
1897	----------	----------
1898	----------	----------
1899	----------	----------
1900	----------	----------
1901	----------	----------
1902	1,800	1 50
1903	5,137	1 91
1904	1,500	2 00

SOLANO COUNTY.

The occurrence of gas in Solano County is reported by W. W. Bradley, as follows:

Natural Gas.

"The Rochester Oil Company, of Suisun, in 1901, drilled a well in Sec. 24, T. 5 N., R. 1 W., elevation 50 feet, struck gas at 1,520 feet, but drilled to 1,820 feet and got nothing more. The gas is piped to Suisun, Fairfield, and Cement. Flow 20,000 cubic feet per day. The brine which accompanies it is evaporated and the salt marketed. There are several other occurrences of natural gas in the same district.

"In the St. Johns quicksilver mine, a thick, dark brown mineral oil, which burns readily when a candle is applied to it, is found in the jointages and fissures in and near the ore bodies."

A prospect well was started near Glen Cove and Vallejo, but as the formation is entirely Cretaceous clay shale a favorable outcome would be surprising as the formation has not yet been found productive in California.

SONOMA AND MARIN COUNTIES.

In Sonoma and Marin counties there are a few known occurrences of oil. The geologic formations are, broadly speaking, three in number: Franciscan (metamorphic), an overlying soft clay and sandstone series varying from possibly 100 to 1,500 feet in thickness, and occasional capping of igneous rock (andesite).

Some geologic work in the region has been done by V. C. Osmont (Department of Geology, University of California, Bulletin 4, No. 3, 1904) and by F. M. Anderson (Department of Geology, University of California, Bulletin 5, No. 2, 1899).

Gas and oil are known to occur at Point Bonita, T. 1 N., R. 8 W., and also about three miles east of Petaluma, T. 4 N., R. 7 W. At the first named locality a well was drilled some ten or fifteen years ago and obtained very heavy oil but not in paying quantity. Near Petaluma two wells have been drilled; the first at a depth of 800 feet encountered gas enough to furnish a few lights. Near this well is a small outcrop of oil stained sand. The second well is 910 feet deep, reporting thin oil sands between the depths of 335 and 400 feet.

Gas is reported from water wells bored near Geyserville, but no useful supply has been developed.

Bitumen in small amounts occurs in the Great Eastern quicksilver mine near Guerneville.

The sand and clay series is, of course, the only one likely to produce oil. In a number of places it contains beds of diatomaceous shale and at several localities lignite exists. In general the structure is regular, bedding being nearly horizontal.

The region offers but little promise owing to slight thickness of formation and scarcity of oil seepages.

MARIN COUNTY.

Gas and asphaltum, in Marin County, are reported as follows by W. W. Bradley, of the State Mining Bureau:

Natural Gas.

''An inflammable gas escapes from the reef at Duxbury Point, near Bolinas. It can be observed only at extreme low tide. It is stated that natural gas has also been found near Nicasio.

Asphaltum.

''Along the shore line cliffs, west of Bolinas from Duxbury Point north for a distance of over three miles, there are several small occurrences of asphaltum which appear to be residues from oil seepages.

''At Abalone Beach there is said to be an oil seepage which is uncovered at extreme low tide. The shales here dip to the south and east, at a rather flat angle (20° to 30°). At the south end of this beach is an unconformity between two series of shales.

''From Bolinas Point to Duxbury Point the shale strata which are somewhat indurated, strike southeast and dip west at 45° to 50°. In the cliffs at Duxbury the asphaltum appears in thin seams, cutting across and nearly normal to the dip of the strata. There are small dabs of asphaltum sticking to the washed reef throughout this section from Duxbury to Abalone.

''At Bolinas the division between the soft yellow sandstone to the east (dip E. at 10° to 15°) and the shales to the west is marked by a vertical fault plane.

''On the mesa back of Duxbury Point (apparently an old sea terrace) two wells were drilled for oil about 1902. It is said that in the second well, which was a few yards from the sea cliff, a small flow of oil was obtained and several drumsful pumped out; that a charge of dynamite was exploded in the well to open up the flow more, but that instead it became choked off entirely. Others state that the oil in the well was some of that hauled out there for fuel for the boilers.''

APPENDIX.

DECISION NO. 2042.

Before the Railroad Commission of the State of California.

Case No. 450.

IN THE MATTER OF THE COMPLIANCE BY OIL PIPE LINES WITH PROVISIONS OF CHAPTER 327 OF THE LAWS OF 1913, DECLARING CERTAIN CORPORATIONS, ASSOCIATIONS AND INDIVIDUALS TO BE COMMON CARRIERS AND PUBLIC UTILTIES, SUBJECT TO THE PROVISIONS OF THE PUBLIC UTILITIES ACT.

Pillsbury, Madison and Sutro, for Standard Oil Company.

Edmund Tauszky, for Associated Oil Company.

Edmund Tauszky, Stanley Moore and *H. C. Booth,* for Associated Pipe Line Company, Salt Lake Oil Company of California, and Amalgamated Oil Company.

T. O. Toland, L. W. Andrews and *Paul M. Gregg,* for Producers Transportation Company.

T. O. Toland and *L. W. Andrews,* for Union Oil Company of California, Puente Oil Company, Mission Transportation and Refining Company and Columbia Oil Producing Company.

Chas. W. Slack and *A. L. Weil,* for General Pipe Line Company of California.

Paul M. Gregg, for Pinal-Dome Oil Company.

L. A. Phillips, for Coast Oil Transport Company, Refining and Producing Oil Company and Graciosa Oil Company.

Geo. W. Lane, for Independent Oil Producers Agency.

John Martin, for Midway Gas Company.

A. L. Hilborn, for Palmer Union Oil Company.

J. T. F. Bayertz, for Murphy Oil Company.

T. O. Turner, for Pacific Pipe Line Company.

Francis J. Heney and *James A. Farraher,* for Independent Oil Producers and Consumers' League.

BY THE COMMISSION.

OPINION.

This is a proceeding on the Commission's own motion to determine whether certain oil pipe line companies are common carriers and public utilities subject to the provisions of the Public Utilities Act. This proceeding was instituted as a result of the passage of chapter 327 of the Laws of 1913, which statute is here inserted in full:

An act declaring certain corporations, individuals, or association of individuals engaged, directly or indirectly, in the transportation of crude oil or petroleum or the products thereof, for hire or otherwise, to be common carriers and public utilities and subject to the provisions of the act known as the public utilities act of the State of California, approved December 23, 1911.

(Approved June 4, 1913.)

The people of the State of California do enact as follows:

SECTION 1. Every private corporation and every individual or association of individuals:

(*a*) Owning, operating, managing or controlling any pipe line or any part of any pipe line, plant or equipment within the State of California for the transportation of crude oil or petroleum or the products thereof, either directly or indirectly, to or for the public, for hire, compensation or consideration of any kind, paid, given, extended or received, directly or indirectly, for such transportation, or engaged, directly or indirectly, in the business of so transporting the same; or

(*b*) Owning, operating, managing or controlling any pipe line or any part of any pipe line, plant or equipment for the transportation of crude oil, petroleum or the products thereof, directly or indirectly, to or for the public, for hire, compensation or consideration of any kind, paid or received, directly or indirectly, for such transportation, and which said pipe line, plant or equipment is constructed or maintained upon, along, over or under any public highway, and in favor of whom the right of eminent domain exists; or

(*c*) Owning, operating, managing or controlling, directly or indirectly, any pipe line or pipe lines, or any part of any pipe line or pipe lines, plant or equipment, or any pipe line system or any part thereof, for the transportation, directly or indirectly, to or for the public, for hire or otherwise, of crude oil, petroleum or products thereof, and which said pipe line, or pipe lines, or plant or equipment, or system, is, or are, constructed, operated or maintained across, upon, along, over or under the right of way of any railroad corporation or other common carrier required by law to transport crude oil, petroleum or products thereof as a common carrier; or

(*d*) Owning, using, operating, managing or controlling, directly or indirectly, or participating in the ownership, use, operation, management or control, directly or indirectly, under lease, contract of purchase, agreement to buy and sell, or other contractual or tacit agreement or arrangement of any kind or character whatsoever, of any pipe line, or pipe lines, or any part of any pipe line, or pipe lines, plant or equipment, or pipe line system, or any part of any pipe line system, for the transportation of crude oil, petroleum or the products thereof, of and from, or of, or from any oil field or place of production within the State of California, to any distributing, refining, or marketing center or reshipping point therefor within said state, whereby, or under, or through which, directly or indirectly, such corporation, or any corporation or association of corporations, or individual or association of individuals secures, or is enabled to secure, or attempts to secure, or tends to secure the control of, or monopoly of the purchasing of, or the control of, or monopoly of the transportation of such crude oil, petroleum or the products theerof.

Is hereby declared to be a common carrier and subject to the provisions of the act known as the "Public Utilities Act," approved December 23, 1911.

SEC. 2. Every corporation organized and existing under the laws of the State of California or under the laws of any other state to transport, or to engage in the business of transporting, within the State of California, any crude oil, petroleum or the products thereof, or for the purpose of acquiring, constructing, leasing, owning, maintaining or operating, directly or indirectly, or of controlling or participating in the control of any pipe line or pipe lines with pumping station or stations, or other appurtenant equipment or plant constructed and maintained, or to be constructed or maintained for the transportation of crude oil, petroleum or the products thereof, actually engaged or engaging in such operation or transportation, directly or indirectly, or shares, directly or indirectly, in the business of such operation or transportation, is hereby declared to be a common carrier and subject to the provisions of the "Public Utilities Act" of the State of California, approved December 23, 1911.

SEC. 3. Any pipe line constructed, acquired, owned, operated, maintained, managed or controlled by any private corporation or individual or association of individuals for any of the purposes or under any of the conditions specified in section 1 or section 2 of this act, is hereby declared to be a public utility and subject to the provisions of the "Public Utilities Act" of the State of California, approved December 23, 1911.

SEC. 4. If any section, subsection, sentence, clause or phrase of this act is for any reason held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this act. The legislature hereby declares that it would have passed this act and each section, subsection, sentence, clause and phrase thereof, irrespective of the fact that any one or more other sections, subsections, sentences, clauses or phrases be declared unconstitutional.

SEC. 5. The provisions of this act are not to be construed as applying to any corporation, individual or association of individuals where the nature and extent of their business is such that the public needs no use in the same, and the conduct of the same is not a matter of public consequence.

The order instituting this proceeding was made by the Commission on August 11, 1913. That order referred to the passage of chapter 327 of the Laws of 1913 and stated that it was now the duty of the Commission to determine what corporations, associations and individuals are subject to the provisions of that act, and to require such corporations, associations and individuals to comply fully with the provisions thereof. The order then stated that after a preliminary investigation it appeared that certain specified corporations may possibly be subject to the provisions of said act, and ordered such corporations to appear before the Commission at a specified time and place "to show cause why the Railroad Commission should not make its order requiring each of said companies to file with this Commission schedules of their rates and charges for the transportation of crude oil and petroleum or the products thereof, and their rules and regulations in connection with such transportation, and otherwise to comply fully with said chapter 327 of the Laws of 1913." The following companies were named in this order:

Standard Oil Company.
Producers Transportation Company.
Associated Oil Company.
Union Oil Company of California.
General Pipe Line Company of California.
Pinal-Dome Oil Company.
Puente Oil Company.
Central Oil Company.
Home Oil Company.
Graciosa Oil Company.
San Luis Obispo Company.
Refining and Producing Oil Company.
Coast Oil Transport Company.
Mission Transportation and Refining Company.
Associated Pipe Line Company.
Salt Lake Oil Company of California.
Amalgamated Oil Company.
Central Oil Company of Los Angeles.
Palmer Union Oil Company.

To this list the following companies were added and brought into the proceeding by subsequent orders of the Commission:

Columbia Oil Producing Company.
Murphy Oil Company.
Pacific Pipe Line Company.
Midway Gas Company.
Independent Oil Producers Agency.
San Luis Obispo Mutual Oil Company.
Pinal-Dome Refining Company.
Bard Oil and Asphalt Company.

In response to this order the Standard Oil Company, on August 14, 1913, filed with the Commission complete schedules of rates and regulations for the transportation of oil through all of the company's lines in the State of California. The company stated that it would, after August 10, 1913, engage in the business of transporting crude oil or petroleum through its pipe lines as a common carrier. These schedules were filed and the system operated as a common carrier, however, under protest against the reasonableness or validity of chapters 285, 286 and 327 of the Laws of 1913, being the so-called oil pipe line statutes.

On August 27, 1913, in the case of *Kern Trading and Oil Company and Associated Oil Company* vs. *Associated Pipe Line Company, Attorney General, Railroad Commission et al.*, a temporary restraining order was obtained from the District Court of the United States in and for the Northern District of California enjoining the Associated Pipe Line Company from complying with the provisions of chapters 285, 286 and 327 of the statutes of California for the year 1913, and also enjoining the other defendants, including the Railroad Commission, from enforcing against that company the provisions of any of these statutes. The constitutionality of these statutes, including chapter 327 under which this proceeding of the Commission is instituted, was challenged in that case upon several grounds. On September 14, 1914, Circuit Judges Gilbert and Morrow and District Judge Dooling, speaking through the latter, rendered their final decision in the case. The court declined to hold that any of these statutes were unconstitutional and refused to enjoin the Associated Pipe Line Company from complying with the provisions thereof. Inasmuch, however, as the bill of complaint averred that the penalties provided for non-compliance with these statutes and the license fees prescribed by chapters 285 and 286 were so severe as to deter the companies from testing the constitutionality of these statutes by the ordinary procedure in the State Supreme Court, the federal court enjoined the attorney general, the Railroad Commission and its attorney from enforcing against the Associated Pipe Line Company any of the penalties or licenses, except the primary fee of $250 which, under these statutes, "have accrued or may accrue at any time before the validity of said pipe line acts have been finally passed upon by the courts of the State of California."

A number of hearings have been held at which testimony has been introduced before the Commission upon the question whether the companies which are parties to this proceeding come within the provisions of chapter 327 of the Laws of 1913 and are subject to the Public Utilities Act. This case is now ready for the findings and order of the Commission.

The record in this case shows that certain of these companies are not engaged in the transportation of any crude oil, petroleum or the products thereof. It is not necessary, therefore, to further consider such companies. The record shows and we find as a fact, that the remaining companies, namely, Standard Oil Company, Producers Transportation Company, Associated Oil Company, Associated Pipe Line Company, General Pipe Line Company of California, Union Oil Company of California, Pinal-Dome Oil Company, Home Oil Company, Salt Lake Oil Company of California, Amalgamated Oil Company, Central Oil Company of Los Angeles, Columbia Oil Producing Company, Murphy Oil Company, and Bard Oil and Asphalt Company, are organized and existing, under the laws of the State of California, to engage in the business of transporting within the State of California, crude oil, petroleum, or the products thereof, and are actually engaged in such transportation.

We shall summarize briefly the evidence relating to the operations of each of these companies, and thereafter consider whether the nature and extent of their business is such that the public needs a use in the same, and the conduct of the same is a matter of public consequence. Before doing so, however, we call attention to the location of the oil fields in California. These fields naturally divide themselves into two territories; those in the San Joaquin Valley in and around Bakersfield and Coalinga, and those along the coast in Santa Barbara, Ventura, Los Angeles and Orange counties. The names of the fields in these two territories and their relative production are indicated by the following report of the production for the month of July, 1913:

San Joaquin Valley.

Name of field	Number of barrels	
Coalinga	1,617,081	
Kern River	766,754	
Maricopa	497,126	
Midway	2,692,001	
McKittrick	366,645	
Belridge	189,610	
Lost Hills	287,646	
Total		6,416,863

Coast.

Santa Maria	423,935
Fullerton	518,646
Salt Lake	237,075
Whittier	68,155
Coyote	249,421
Ventura	73,374
Newhall	8,621
Los Angeles	26,905
Summerland	4,350
Total	1,610,482
Total for state	8,027,345

It is impossible to entirely segregate the testimony with reference to each company, but we shall endeavor to do so as far as is necessary to give a complete understanding of the operations of each company.

Standard Oil Company.

Standard Oil Company, formerly known as Pacific Coast Oil Company, was incorporated on September 7, 1879. This company now handles approximately 30 per cent of the total crude petroleum production of the state. The company has refineries at Richmond, Contra Costa County, at El Segundo near Redondo, in Los Angeles County, and at Seguro near Bakersfield, in Kern County. These refineries are operated continuously, and the greater part of the refined oil is sold in the Orient. The company also markets its production in the Pacific Coast states, Hawaiian Islands, British Columbia and the west coast of Central and South America.

The pipe line system of the company had its inception in 1895 and has expanded with the development of the oil industry. The company at present has the following lines in operation:

1. Newhall to Ventura, a distance of 44.19 miles, 28.3 miles of which is a 3-inch line and the remainder a 2-inch line. The capacity of this line is 1,400 barrels per day.

2. A double 8-inch line from Bakersfield to Richmond, a distance of 280.6 miles. The capacity of this double line is 65,000 barrels per day.

3. A branch of the Bakersfield-Richmond line has been constructed from Coalinga to Mendota, a distance of 29.2 miles. This branch is an 8-inch line with a capacity of 28,000 barrels per day.

4. Another branch of the Bakersfield-Richmond line has been constructed from Lost Hills to Pond. This is an 8-inch line 21.1 miles in length and has a capacity of 20,000 barrels per day.

5. A double 8-inch branch line from Midway to Bakersfield, a distance of 32.2 miles. The capacity of this double line is 65,000 barrels per day.

6. A 6-inch line from Northam to El Segundo, on the coast of Los Angeles County, a distance of 23.9 miles, with a capacity of 9,000 barrels per day.

7. An 8-inch line from Orcutt to Port San Luis, on the coast of San Luis Obispo County, a distance of 32.52 miles, with a capacity of 20,000 barrels per day.

Each of these seven lines crosses public highways. Each of these lines, except the Coalinga-Mendota line, crosses railroad rights of way. The Bakersfield-Richmond line also runs along railroad rights of way for short distances.

The Standard Oil Company does not, itself, produce all the oil transported by it. By far the greater part of the oil transported is purchased in the fields from other producers. For instance, of the 65,000 barrels per day transported through the Bakersfield-Richmond line only 39,000 barrels are produced by the Standard Oil Company. The 65,000 barrels per day carried through the Midway-Bakersfield branch include only 35,000 barrels of Standard Oil production.

While the Coalinga-Mendota line has a capacity of 28,000 barrels per day, it is carrying only 23,000 barrels per day, the remainder of the production in this field being handled through other pipe lines. Yet, of this 23,000 barrels the Standard Oil Company produces only 2,000. The Lost Hills-Pond branch is now carrying only 5,000 barrels per day, of which the Standard Oil Company produces 1,500. The company purchases a large amount of oil which is temporarily placed in storage. In fact, the Standard Oil Company purchases in the San Joaquin Valley fields 50,000 barrels per day in excess of its own production in these fields.

Referring now to the lines of the Standard Oil Company from the coast fields, the record shows that the Newhall-Ventura line is being operated to its full capacity of 1,400 barrels per day, of which the Standard Oil Company, itself, produces only 200 barrels. The Northam-El Segundo line is carrying its full capacity of 9,000 barrels per day, of which the Standard Oil Company produces 6,000. The Orcutt-Port San Luis is at present carrying only 200 barrels per day, none of which is produced by the Standard Oil Company.

Producers Transportation Company.

An understanding of the operation of this company requires a short review of the history of its organization by the Independent Oil Producers Agency in 1904. The Independent Oil Producers Agency was formed by a number of independent oil producers in the Kern fields, who united for the purpose of forming an organization which would represent a sufficiently large oil production to attract capital to construct a pipe line from the oil wells to the market, and also for the purpose of marketing their oil to the best advantage. At that time the independent producer in the Kern fields was absolutely at the mercy of the Standard Oil Company and the Associated Oil Company. These companies owned the only pipe lines transporting oil from those fields. The independent producer had to either sell his oil to these companies at prices named by them, or else not sell his oil at all. The same condition exists in the Coalinga fields with the result that many of the producers, being unable to procure what they considered to be a fair contract price for the transportation of their oil, were compelled to take the only other alternative and shut down their wells. These conditions prompted the formation of the Coalinga Oil Producers Agency in 1907, which was later absorbed by the Independent Oil Producers Agency.

On August 1, 1913, the Independent Oil Producers Agency had 175 members. These members were producers in the Coalinga, Kern, McKittrick, Midway and Maricopa fields. The Agency represents a production of 1,500,000 barrels of fuel oil per month, which is approximately 22 per cent of the state's entire production.

The Independent Oil Producers Agency procured the formation of the Producers Transportation Company on June 10, 1909, with an authorized capital stock of the par value of $7,000,000. An arrangement was made between the Producers Transportation Company and the Union Oil Company of California for the financing of a pipe line to be constructed from the oil fields in the San Joaquin Valley to the coast. The Union Oil Company of California, hereinafter called the Union Oil Company, furnished to the Producers Transportation Company the sum of $3,500,000, to be used in the construction of such a line. The Producers Transportation Company delivered to the Union Oil Company $6,999,300 par value of its stock, being all of the stock except seven shares, qualifying directors, and also delivered to the Union Oil Company $3,500,000 face value of bonds. Under this arrangement the Producers Transportation Company constructed, and now has in operation, the following pipe line system:

1. Eight-inch line, about 40 miles, from the Coalinga fields south to a point known as Junction Station, in Kern County.
2. Eight-inch line, about 40 miles, from the Maricopa fields north through the Midway and McKittrick fields to Junction Station.
3. Eight-inch line, about 30 miles, from the Kern River fields west to McKittrick.
4. Six-inch line, about 30 miles, from the Lost Hills fields west to Junction Station.
5. Six-inch line, about 4 miles, from the Belridge fields northeast connecting with the McKittrick Junction Station line.
6. A double 8-inch line, about 70 miles, from Junction Station west to Port Harford, on the coast of San Luis Obispo County.

This pipe line system is constructed across public highways in Fresno, Kings, Kern and San Luis Obispo counties. The company has a franchise from the county of San Luis Obispo and from the city of

San Luis Obispo for the construction of its pipe line along certain highways in said county and city. The pipe lines of this company also run along the right of way of the Southern Pacific Railroad Company and the Pacific Coast Railway Company for an aggregate distance of approximately five miles.

On December 18, 1909, the company obtained a judgment and decree in condemnation in the case of *Producers Transportation Company* vs. *Gaspar O. Marre et al.,* an eminent domain proceeding instituted in the superior court of San Luis Obispo County. The complaint of the Producers Transportation Company in that proceeding alleges that "plaintiff is engaged in the business of transporting oil by means of pipe lines as a common carrier for hire."

We shall now briefly consider the operations of the Producers Transportation Company. That company, itself, produces no oil. It has confined its operations to carrying oil delivered to it by the Independent Oil Producers Agency. Each member of the Agency owns one share of stock in the Agency. The Union Oil Company is a member of the Agency and produces a far greater amount of oil than any other member. Each member of the Agency is required to sign a ten-year contract, by which he agrees to deliver to the Agency, for sale, all of the petroleum produced by him on specified lands. This contract runs with, and binds the lands of the producer, for the full performance of the provisions of the contract. On June 11, 1909, a contract was made between the Agency and the Producers Transportation Company whereby the latter was given the exclusive right, for a period of ten years, to transport at specified rates, all fuel oil of the Agency. A similar contract was required between the Producers Transportation Company and each member of the Agency. The members of the Agency can not, under the provisions of these contracts, transport fuel oil produced by them except through the lines of the Producers Transportation Company. On June 24, 1909, a contract was made between the Agency and the Union Oil Company, whereby the latter was made the exclusive sales agent for a period of ten years, of all the fuel oil of the Agency. The Union Oil Company receives a commission for acting in this capacity. This contract provides for an arbitration committee consisting of four members, which committee shall "determine all questions or matters which may arise under, respecting, or in any way connected with this contract."

The contract further provides that this arbitration committee is to consist of two members appointed by the Union Oil Company and two members appointed by the Agency. On April 1, 1912, a contract was made between the Agency and the Union Oil Company, whereby the latter agreed to provide ten million barrels storage capacity for the Agency during a period of excessive production. In this contract the

Agency agreed, among other things, that it would take no new members during the term of the contract without the consent of the Union Oil Company.

The Producers Transportation Company owns no facilities for carrying the oil from Port Harford. The oil is handled from this point by vessels owned or chartered by the Union Oil Company, and an additional charge is made by that company for the use of these vessels.

Associated Oil Company.

The Associated Oil Company, which was incorporated on October 5, 1901, with power to pipe and carry oil and also to exercise the right of eminent domain, now owns and operates two oil pipe lines, as follows:

1. An 8-inch line from the Santa Maria fields to Gaviota, on the coast of Santa Barbara County, a distance of 30 miles. There is an 8-mile branch from this line running to the Cat Canyon fields.
2. A 6-inch line from the Coalinga fields to Monterey, on the coast of Monterey County, a distance of 105 miles.

Both of these lines are constructed along public highways and also cross railroad rights of way.

The main Gaviota line has a capacity of 15,000 barrels per day and is used to capacity for the transportation of oil, none of which is produced by the Associated Oil Company. The branch line from the Cat Canyon fields is not now in operation. The Associated Oil Company and the Union Oil Company each owns one half of the stock of the California Coast Oil Company, which produces about 30,000 barrels of oil per month in fields served by the Gaviota line. The oil produced by the California Coast Oil Company is taken in alternate months by the two controlling companies.

The Monterey line is operated to its full capacity of 15,000 barrels per day. Of this amount the Associated Oil Company only produces 2,000 barrels per day. The Associated Oil Company has contracts for the purchase of oil in all the San Joaquin Valley fields except the Kern fields. Some oil is purchased in the latter field on the market. Upon arrival at Monterey the oil is re-shipped by rail or vessel to the most advantageous markets.

Oil produced by the Associated Oil Company and tied up to that company by contracts amounts to about 22 per cent of the entire production of the state.

Associated Pipe Line Company.

On April 15, 1907, the Associated Oil Company and the Kern Trading and Oil Company entered into an agreement for the organization of the "Associated Pipe Line Company," to transport oil for the two organizers, each of which would be entitled to use one half of the capacity of the lines operated by the Associated Pipe Line Company.

On August 20, 1907, the Associated Pipe Line Company was incorporated "for the acquisition, construction, leasing, owning, maintenance and operation, but not as a common carrier, of pipe lines for the transportation of oil within the State of California." This company now has in operation two lines:

1. An 8-inch line, known as the "Rifled" line, from Volcan, a station about 3 miles east of Bakersfield, in Kern County, to Port Costa, on the coast of San Francisco Bay, a distance of approximately 281 miles.
2. An 8-inch line known as the "Hot" line, from the Sunset-Midway fields, in Kern County, to Port Costa, a distance of approximately 278 miles.

The Rifled line is constructed entirely upon railroad rights of way. It is constructed along the right of way of the Southern Pacific Railroad Company from Volcan to Goshen, then along the Central Pacific Railway Company's right of way from Goshen to Fresno, and for the remainder of the distance is constructed upon the right of way of the Southern Pacific Railroad Company. The line also crosses a number of public highways. The capacity of the line is 13,000 barrels per day.

The Hot line is constructed along the right of way of the Southern Pacific Railroad Company from Mendota to Port Costa, a distance of approximately 140 miles. The line crosses a number of highways, and in Kern County runs along a public highway for a short distance. The capacity of this line is 26,000 barrels per day.

The lines of the Associated Pipe Line Company are used to full capacity, one half by the Kern Trading and Oil Company and one half by the Associated Oil Company, each of which companies owns 50 per cent of the stock of the Pipe Line Company. The Kern Trading and Oil Company is a subsidiary of the Southern Pacific Company, which owns all of its stock except qualifying shares for directors. The Southern Pacific Company also owns 51 per cent of the stock of the Associated Oil Company.

All the oil carried through these lines for the account of the Kern Trading and Oil Company is produced by that company, and is delivered to, and consumed by, the Southern Pacific Company. Before the production of the Kern Trading and Oil Company was equal to one half of the capacity of these lines it purchased oil in the fields from other producers, including the Associated Oil Company, the oil thus purchased being carried through the Associated Pipe Line Company's lines.

The oil carried through these lines to the account of the Associated Oil Company is either produced or purchased by that company in the fields. In the fields tributary to the lines of the Associated Pipe Line Company, the Associated Oil Company produces about 16,500 barrels per day and in addition purchases about 30,000 barrels per day.

Approximately 20,000 barrels per day are delivered by the Associated Oil Company to the Associated Pipe Line Company for transportation. All the oil of the Associated Oil Company transported through these lines is sold by the Associated Oil Company on the market.

General Pipe Line Company of California.

The General Pipe Line Company of California, hereinafter called the General Pipe Line Company, was incorporated February 28, 1912, with power "to carry on the business of transporting for hire petroleum and other mineral oils, by means of pipe lines." The company was also given the power to "condemn" property. The General Pipe Line Company now owns and operates a main and branch oil pipe line as follows:

1. Main Line: An 8-inch line from the Midway fields in Kern County, south over the Tehachapi mountains to San Pedro in Los Angeles County, a distance of 156 miles.
2. Branch Line: An 8-inch line from Lebec, in Los Angeles County, east to Mojave in Kern County, a distance of 51.82 miles.

The capacity of the main line and of the branch line is from 25,000 to 30,000 barrels per day.

The main line is constructed upon and crosses railroad rights of way. This pipe line system is also constructed along public highways. The company has received franchises for the construction of its lines from Los Angeles County and the cities of Los Angeles, Huntington Park, San Fernando, Burbank, Vernon, Tropico, Glendale and Newhall. Ordinance No. 24874, new series, of the city of Los Angeles, being the franchise under which the General Pipe Line Company has constructed its line within that city, provides in section 17 "that the pipe line system constructed, operated and maintained under said franchise, shall be deemed to be a public utility and shall be operated as a public utility at all times," and provided further that the city of Los Angeles should have the right to fix the rates to be charged for carrying oil through said pipe line system. Substantially the same provision is contained in section 11 of Ordinance No. 26295, new series, of the city of Los Angeles granting to the General Pipe Line Company certain rights in Los Angeles harbor. Ordinance No. 299, new series, of the county of Los Angeles granting the franchise under which the General Pipe Line Company constructed its lines in said county, provides in section 4, "That the grantee of this franchise shall supply oil of sufficient quality and quantity upon application to any manufacturing or industrial concern located on the route of said pipe line upon paying the necessary cost of making connections with the pipe line and the reasonable market value of the oil, and shall supply oil at any place upon said pipe line to the county of Los Angeles upon the same conditions." Substantially similar provisions are contained in the franchises granted by the cities of Burbank, San Fernando and Huntington Park.

The General Pipe Line Company has constructed its line through the Santa Barbara National Forest, under permit from the Department of the Interior, and along the outer breakwater at San Pedro, under permit from the Department of War of the federal government.

The General Pipe Line Company, itself, produces no oil. The company has entered into a contract to transport the oil of the General Petroleum Company, which company completely controls the General Pipe Line Company. The General Petroleum Company, itself, produces approximately 9,000 barrels of oil per day from lands tributary to the lines of the General Pipe Line Company. The remainder of the capacity of the lines of this company is used to transport oil purchased by the General Petroleum Company. The General Petroleum Company controls, through production and purchase, from 10 to 12 per cent of the entire production of the state.

Union Oil Company of California.

The operations of the Union Oil Company of California, hereinafter called the Union Oil Company, as a member of the Independent Oil Producers Agency, and as the marketing agent for that Agency have already been considered. In addition to these operations the Union Oil Company operates pipe lines in Los Angeles, Ventura, Santa Barbara and San Luis Obispo counties. These pipe lines are owned by the Union Transportation Company and the Mission Transportation and Refining Company, all of the stock of which companies, except qualifying shares, is owned by the Union Oil Company. The lines are leased to, and operated by, the Union Oil Company. A description of these lines is set forth in Exhibit H of the Union Oil Company, as follows:

Name	Size	Length in miles	From	To	Owned by	Operated by
Lompoc Pipe Line	6 inch	32.47	Orcutt	Port San Luis.	Union Transportation Company.	Union Oil Company.
	8 inch	32.47				
		64.94				
Ventura Pipe Line	3 inch	9.75	Fillmore	Sespe.	Mission Transportation and Refining Company.	Union Oil Company of California.
	4 inch	23.00	Sespe	Ventura.		
	4 inch	10.00	Ventura	Oxnard.		
		42.75				
Los Angeles Pipe Line.	6 inch	9.48	Stewart	Norwalk.	Mission Transportation and Refining Company.	Union Oil Company of California.
	6 inch	14.26	Los Angeles	Norwalk.		
	8 inch	10.96	Sherman	Los Angeles.		
	8 inch	7.26	Norwalk	Bixby.		
	6 inch	9.41	Bixby	East San Pedro.		
		51.37				

These lines are constructed along and across public highways. Franchises for their construction have been granted by the counties of Los Angeles, Santa Barbara, Ventura, San Luis Obispo and also by the cities of Los Angeles and Long Beach. A portion of the Santa Barbara County line is constructed upon the right of way of the Pacific Coast Railway Company and a portion of the Los Angeles County line is constructed upon the right of way of The Atchison, Topeka and Santa Fe Railway Company.

The answer filed by the Union Oil Company states that that company "has transported and does transport crude petroleum in the excess capacity of said Los Angeles County and said Santa Barbara County lines—remaining after all of the requirements of this respondent have been met—under private contract, on specific terms for a reasonable compensation." The company is at present carrying oil for others under contracts as follows: (1) a contract executed January 21, 1908, between Albert M. Stephens, Margarita Guinardo Dallugge, Adolph Ramish, Martin C. Marsh and the Union Oil Company, by which the latter agrees for a period of ten years to carry through its lines to Los Angeles at a stated compensation, oil produced by the former upon a certain tract of land. (2) Contract executed July 1, 1908, between Emma Summers, Callie M. Parker and the Union Oil Company, whereby the latter agrees for a period of approximately nine years to carry oil at a stated compensation from the Fullerton field through its lines to Los Angeles. (3) Contract executed February 26, 1901, in which the Union Oil Company agrees to transport, for stated compensation, the oil of the Columbia Oil Producing Company produced upon a certain tract in Orange County. The Union Oil Company has also in the past transported, for compensation, oil of various other producers.

Salt Lake Oil Company of California.

Salt Lake Oil Company of California was incorporated on November 25, 1903, with power "to transport and carry for hire" oils, petroleum and the products thereof. All of the stock of this company, except qualifying shares, is owned by Amalgamated Oil Company. The Salt Lake Company owns and operates an 8-inch line from the Salt Lake fields into the city of Los Angeles, a distance of approximately ten and one half miles. This line is constructed along public highways under franchises from Los Angeles County and the city of Los Angeles, and also crosses the right of way of the Southern Pacific Company. The capacity of the line is 7,500 barrels per day. All the oil transported through this line is delivered to the Amalgamated Oil Company in Los Angeles.

While this line is owned by the Salt Lake Oil Company of California, it is used to transport, not only the oil of that company, but also oil produced or purchased by the Amalgamated Oil Company and oil produced by the Arcturus Oil Company all of the stock of which, except qualifying shares, is owned by the Amalgamated Oil Company. Each of these companies, while its own oil is being transported through the line, assumes complete charge thereof, and pays the entire expense of the labor and power used to pump the oil through the line.

Amalgamated Oil Company.

The Amalgamated Oil Company was incorporated on October 14, 1904. A majority of the stock of this company is owned by the Associated Oil Company. The Amalgamated Oil Company owns and operates a line about six and one-half miles in length, which is constructed entirely within the limits of the city of Los Angeles. The line has been constructed along public highways under a franchise granted by the city of Los Angeles and is also constructed for a short distance along the right of way of The Atchison, Topeka and Santa Fe Railway Company. The main portion of the line is a 6-inch line, although there are branches of 3, 4 and 4½-inch lines. The capacity of the main line averages 9,000 barrels per day.

This line is used solely to transport oil produced or purchased by the Amalgamated Oil Company, and thereafter sold and distributed by that company.

Pinal-Dome Oil Company.

Pinal-Dome Oil Company owns and operates a 4-inch line nine miles in length with a capacity of 3,000 barrels per day. The line is used solely to transport oil, produced by Pinal-Dome Oil Company, from lands owned by it in the Santa Maria fields, in Santa Barbara County. The oil is carried to the company's own refinery at Betteravia, a station on the Pacific Coast Railway. At this point the oil is refined and marketed. The pipe line is constructed chiefly along a private right of way, although it crosses two public highways and also the right of way of the Pacific Coast Railway Company.

Columbia Oil Producing Company.

Columbia Oil Producing Company owns and operates a three-inch line from the Fullerton fields, in Los Angeles and Orange counties, to Chino, a town about sixteen miles east in San Bernardino County. There are two short branches of this line, each constructed of two-inch pipe. The capacity of the line is from 1,000 to 1,500 barrels per day. The line crosses public highways but is constructed over no rights of way. The company uses this line to transport only oil produced by its own wells. The oil is refined at the company's refinery at Chino and there marketed.

Murphy Oil Company.

This company owns and operates two four-inch pipe lines: (1) The "Murphy" line from East Whittier to Los Nietos, a distance of 4.75 miles and having a capacity of 50 barrels of oil per hour, and (2) "Coyote" line from Coyote to Los Nietos, a distance of 6.34 and having a capacity of 100 barrels per hour. These lines cross public highways, but are constructed over no railroad rights of way and are used solely to transport the company's own oil.

Bard Oil and Asphalt Company.

This company owns and operates a 4-inch line from Ojai Valley in Ventura County to the tracks of the Southern Pacific Company, in Santa Paula, a distance of eight and one half miles. This line is constructed along public highways under franchises from Ventura County and the city of Santa Paula. The line has a capacity of from 100 to 250 barrels per day.

There are no other companies operating in this field except the Ojai Oil Company. The Bard Oil and Asphalt Company, in addition to carrying its own oil, is transporting oil for the Ojai Oil Company.

Central Oil Company of Los Angeles.

This company operates a 4-inch line from its own wells in Los Angeles County to the tracks of the railroad, a distance of approximately four and one half miles, and carries only oil produced by it.

This completes the summary of the operations of each of the companies which, under the finding made above, are actually engaged in the business of transporting, within this state, crude oil or petroleum or the products thereof. We shall now consider the remaining question of whether the business is such that the public needs use in the same, and that the conduct of the same is a matter of public consequence under the provisions of section 5 of chapter 327 of the Laws of 1913. We shall not here discuss the constitutionality of chapter 327 of the Laws of 1913. While some of the companies which are parties to this proceeding have questioned the constitutionality of that act, that question is clearly one for the determination of the courts, and not this Commission. The constitutionality of that act will be assumed in this proceeding. We desire, however, in passing, to answer to objections advanced against declaring oil pipe lines to be common carriers. Counsel for one of the larger companies frankly stated that he believed the oil pipe lines should be regulated, but objected to having them declared common carriers. His position is that certain of these lines were constructed with a view to transporting oil of certain gravities only, and are not adapted to carrying every kind and quality of oil. The objection was also made that it would be impracticable to require a line to transport oil of all gravities, as there would be an injurious mixing of oils of different gravities. It was further urged that producers who have outstanding contracts for the transportation should be allowed a priority if the lines are found to be common carriers. It appears to us, however, that these contentions do not go to the root of the power of the legislature to declare oil pipe lines to be common carriers. The declaration that they are common carriers does not preclude a regulatory body from authorizing a schedule of rates and rules which shall limit the carriage to certain specified gravities of oil or from authorizing rules which will prevent the injurious intermingling of oils of different gravities. In the same manner regulations may, if it is deemed proper, allow priorities in the transportation of oil to parties who have outstanding contracts for such transportation. These are all questions of regulation and do not, in our opinion, foreclose a declaration that oil pipe lines are common carriers.

In considering the monopolistic features of the oil pipe line business in California we desire first to refer to the history of the Producers Transportation Company. It was claimed that the presence of this company in the field prevented any monopoly in the oil pipe line business. The record, however, shows that while the Producers Transportation Company prevented monopoly in the oil pipe line business when that company was first created, it can not be expected to indefinitely exert this beneficent influence. The record is very specific that the time when the Independent Oil Producers Agency was formed in 1904, the Standard Oil Company and the Associated Oil Company enjoyed an absolute monopoly of the transportation of oils from the San Joaquin Valley fields. The independent producer was compelled to either sell his oil to these companies at prices named by them or else not sell his oil at all. The Independent Oil Producers Agency procured the formation of the Producers Transportation Company, which constructed a pipe line from these oil fields to the Pacific Coast, and in so doing unquestionably afforded to the independent producer a measure of relief from the existing monopoly. Let us consider for a moment, however, the conditions under which this company operates at present. If an independent producer desires to transport his oil over the line of the Producers Transportation Company he must fulfill several requirements. He must sign a ten-year contract to turn over to the Independent Oil Producers Agency all the oil produced by him upon certain defined lands. This contract runs with and bonds the land as a guarantee of his fulfillment of the provisions thereof. He must agree that during the term of this contract the Producers Transportation

Company shall be the exclusive carrier of his oil. He must consent to have the Union Oil Company the exclusive sales agent for his oil. The Union Oil Company is also a member of the Agency and owns all of the stock, except qualifying shares, of the Producers Transportation Company. He must agree that the Union Oil Company and the Agency may each appoint two members of an arbitration committee which shall decide all questions relating to the marketing of his oil. The record further shows that this same Union Oil Company was able, during a certain period of excessive production, when it furnished to the Agency certain storage facilities to require the Agency to agree to take in no new members without the consent of the Union Oil Company. During this period the Union Oil Company had an absolute veto power upon the selection of new members for the Agency. We set forth these facts at length in order to show the requirements which must be fulfilled by any producer desiring to avail himself of the privileges of the Producers Transportation Company line. With these requirements imposed upon the independent producer the opportunity for him to escape the monopoly by joining the Agency is not, in our opinion, entirely clear. He is required to comply with conditions which would never be imposed by oil pipe lines which are common carriers. He is required to turn over to others the handling and sale of his oil. Under these conditions we can not agree that the Producers Transportation Company absolutely precludes the possibility of a monopoly existing in the oil pipe line business in California.

In addition to the Producers Transportation Company there are four other companies operating pipe lines from the San Joaquin Valley fields, namely, Standard Oil Company, Associated Oil Company, Associated Pipe Line Company and General Pipe Line Company of California. Only two of these companies—the Standard Oil Company and the Associated Oil Company—produce any of the oil transported by them. Even in these cases the amount of oil produced is far less than the amount of oil purchased and transported. The Standard Oil Company purchases 50,000 barrels per day in excess of its production in these fields. The Associated Oil Company produces only 2,000 barrels of the 15,000 barrels per day transported through its Monterey line. This company also purchases oil which is transported through the line of the Associated Pipe Line Company.

None of these companies, themselves, consume the oil transported. All the oil carried through the lines of the Associated Pipe Line Company for the account of the Kern Trading and Oil Company is sold to, and consumed by, the Southern Pacific Company. All of the oil carried through these lines of that company for the account of the Associated Oil Company and all the oil transported through the lines of the

Standard Oil Company, the Associated Oil Company, Producers Transportation Company and the General Pipe Line Company is sold upon the market.

The record clearly shows that these pipe lines are the only efficient means of conveying oil from the San Joaquin Valley fields to the markets. The oil of the independent producer is being purchased in the fields by the large oil companies and then transported to the market through these pipe lines. The oil markets are at great distances from the producing wells. The independent producer can not, himself, construct a line to carry his oil. The expense of constructing such a line is prohibitive. For this reason the oil pipe lines have an advantage over the independent producer. If the oil of the independent producer is to reach the market at all, it must be transported through one of these pipe lines. To have his oil transported, he must sell it in the field to one of the large oil companies.

Under these circumstances it would naturally be expected that the oil pipe line companies could dictate the prices at which the independent producer should sell his oil to them.

The record shows the companies are doing this very thing. There is a remarkable uniformity in the price offered by all of these companies for the oil of the independent producers. The record is specific that the General Petroleum Company adopts the price named by the Standard Oil Company; that representatives of the Associated Oil Company and the Union Oil Company frequently confer upon the price to be offered the independent producer, and that no company has ever underbid a price named by the Associated Oil Company. In our opinion these facts, relative to the price offered for the oil of the independent producer could not exist under free competition in the bidding for that oil. It is clearly evident that these large oil companies in the San Joaquin Valley control the price at which the independent producer is required to sell his oil to them.

The control of the oil production in this state has an important bearing upon the question of monopoly in the oil pipe line business. The record shows that of the state's entire production the Standard Oil Company controls 30 per cent, the Associated Oil Company 22 per cent, the Independent Oil Producers Agency, which controls the Producers Transportation Company line, 22 per cent, the General Petroleum Company which controls the General Pipe Line Company of California 11 per cent and the Kern Trading and Oil Company, which uses one half of the capacity of the lines of the Associated Pipe Line Company, 10 per cent. Ninety-five per cent of the entire oil production of this state is controlled by these five companies. By far the greater portion of this oil is purchased by these companies from the independent producer in the fields. These companies have become the exclusive buyers of the oil of the independent producer. The complete control which these companies may exert over the independent producer in the disposition of his oil is obvious. We find as a fact that Standard Oil Company, Associated Oil Company, Producers Transportation Company, Associated Pipe Line Company and General Pipe Line Company of California have secured the control and monopoly of the transportation of crude oil, petroleum and the products thereof from the San Joaquin Valley oil fields.

The purpose of chapter 327 of the Laws of 1913 is to terminate and prevent a monopoly in the oil pipe line business. After defining what corporations, individuals or association of individuals engaged in the oil pipe line business are common carriers and public utilities, section 5 excepts from the provisions of the act companies, individuals and association of individuals, when the nature and extent of their business is not of public interest or consequence. The five companies serving the San Joaquin Valley fields can not be regarded as coming within this exception. We therefore further find as a fact that the nature and extent of the business of the Standard Oil Company, Associated Oil Company, Producers Transportation Company, Associated Pipe Line Company and General Pipe Line Company of California are such that the public needs a use in the same and the conduct of the same is a matter of public consequence.

We shall now consider the pipe lines which carry oil from the Coast fields. The record contains practically no evidence relative to the existence of a monopoly or public need in the use of these lines. The Standard Oil Company and Associated Oil Company each has a line, and the Union Oil Company has two lines from the fields in Santa Barbara County to Port San Luis, a distance of approximately 32 miles. The production in these fields is rapidly decreasing. While the capacity of the Standard Oil Company line is 20,000 barrels per day, only 200 barrels per day are being carried through that line. A line from these fields formerly operated by the Graciosa Oil Company is now abandoned and idle. The record is equally barren of testimony with reference to a monopoly or public need in the use of the other lines of the Standard Oil Company and the Union Oil Company from the Coast fields in Ventura and Los Angeles counties. We accordingly find that the nature and extent of the business of transporting crude oil, petroleum or the products thereof through the lines of the Standard Oil Company, Associated Oil Company and Union Oil Company from the Coast fields in Santa Barbara, Ventura and Los Angeles counties are not such that the public needs a use in the same, and the same are not a matter of public consequence. This finding is, of course, made solely upon the record in this proceeding.

The Salt Lake Oil Company of California operates a line ten and one half miles in length from the Salt Lake fields into the city of Los Angeles, and the Amalgamated Oil Company operates a line approximately six and one half miles in length entirely within the city of Los Angeles. There is no evidence of the existence of a monopoly or public need in the use of the lines of these two companies. It may be that the lines are so short that monopoly of the business in that territory is impossible, and that there are other efficient means of transporting the oil. We find on the record in this case that the lines of these companies come within the exception in section 5 of chapter 327 of the Laws of 1913.

The Bard Oil and Asphalt Company operates a line approximately eight and one half miles in length, from the Ojai Valley in Ventura County to the tracks of the Southern Pacific Company in the city of Santa Paula. This line serves a territory in which there are no other producing wells except those of this company and the Ojai Oil Company. The oil of the latter company is now being carried through this pipe line. There is no monopoly nor public interest in the oil transportation business conducted by this line, and we accordingly find that the Bard Oil and Asphalt Company also comes within the exception in section 5 of chapter 327 of the Laws of 1913.

We have now considered all of the companies which are parties to this proceeding except the Pinal-Dome Oil Company, Columbia Oil Producing Company, Murphy Oil Company and Central Oil Company of Los Angeles. The lines of these companies are only a few miles in length and are used only to transport oil produced by the company which owns and operates the line. These companies clearly come within the exception of section 5 of chapter 327 of the Laws of 1913.

We submit herewith the following form of order:

ORDER.

This proceeding having come on regularly for hearing and the Commission being duly advised in the premises,

The Commission finds as a fact every statement of fact and finding of fact in the foregoing opinion;

The Commission further finds as a fact that Standard Oil Company, Associated Oil Company, Producers Transportation Company, Associated Pipe Line Company and General Pipe Line Company of California are common carriers and public utilities, subject to the provisions of the Public Utilities Act of this state, in the transportation of crude oil, petroleum or the products thereof, by means of pipe lines from the San Joaquin Valley oil fields.

It is hereby ordered that Associated Oil Company, Producers Transportation Company, Associated Pipe Line Company and General Pipe

Line Company of California file with this Commission schedules of their rates and charges for the transportation of crude oil, petroleum or the products thereof by means of pipe lines from the San Joaquin Valley oil fields in the State of California, and their rules and regulations in connection with such transportation.

As Standard Oil Company has already filed with this Commission its schedules of rates and charges and its rules and regulations for the transportation of crude oil, petroleum and the products thereof by means of pipe lines from the San Joaquin Valley oil fields, it is not necessary to include that company in the order herein.

Dated at San Francisco, California, this 31st day of December, 1914.

JOHN M. ESHLEMAN,
H. D. LOVELAND,
ALEX GORDON,
MAX THELEN,
EDWIN O. EDGERTON,
Commissioners.

BIBLIOGRAPHY.

The following list includes the publications of the California State Mining Bureau, United States Geological Survey and United States Bureau of Mines, besides references to articles in other publications. It is arranged alphabetically by counties and subjects and is presented with the hope that it may at least furnish a clue to the published information on the oil industry of California:

Alameda County.

California State Mineralogist's Report, 13, p. 570, 1896.
California State Mineralogist's Report, 8, p. 25, 1888.
Watts, W. L., California State Mineralogist's Report, 11, pp. 121-138, 1893.
Goodyear, W. A., California State Mineralogist's Report, 8, pp. 309-324, 1890.
Watts, W. L., California State Mining Bureau Bulletin 19, p. 151, 1900.
Livermore Gas.
Mining and Scientific Press, Vol. 22, p. 167, 1871.

Belridge Field. See Kern County.
Beverly Hills Field. See Los Angeles County.
Brea Canyon Field. See Los Angeles County.

California.

Oil Regions in Tulare Valley.
Blake, W. P., Proceedings California Academy Sciences, Vol. 3, p. 193, 1867.
Origin and Occurrence of Oil.
Cooper, A. S., Mining Industry, pp. 505-509, 1901.
Present and Future Supply as Fuel on the Pacific Coast.
Bell, A. F. L., Journal of Electricity, Power and Gas, Vol. 26, p. 237-9, 1911.
Oil and Gas Yielding Formations of the Central Valley of California.
Watts, W. L., California State Mining Bureau Bulletin No. 3, p. 95, 1894.
Watts, W. L., California State Mining Bureau Bulletin No. 19, p. 224. 1900.
Petroleum, Asphaltum and Gas.
Goodyear, W. A., California State Mineralogist's Report, 7, pp. 63-114, 188
Oilfields of California.
Lakes, A., Mines and Minerals, Vol. 21, pp. 467-470, 1901.
Production and Use of Petroleum in California.
Prutzman, P. W., California State Mining Bureau, Bulletin 32, p. 227, 1904.
The Petroleum Fields of California.
Eldridge, G. H., U. S. Geological Survey, Bulletin 213, pp. 306-321.
Petroleum in California.
O'Neill, E., Journal American Chemists' Society, Vol. 25, No. 7, pp. 699-711, 1903.
Petroleum in Southern California.
Prutzman, P. W., California State Mining Bureau, Bulletin 63, 419 pp., 1913.
California Oil Field Conditions and Production, 1875-1910.
Requa, M. L., American Institute Mining Engineers, Vol. 42, pp. 837-846.
Petroleum in California.
Silliman, Benjamin, Jr., American Journal Science, 2d Series, Vol. 40, pp. 1-19, 1865.
Naphtha and Illuminating Oil from California Crude.
Silliman, Benjamin, Jr., American Journal Science, 2d Series, Vol. 43, pp. 242-246, 1867.
Future Oil Production in California.
McLaughlin, R. P., Western Engineering, Vol. 1, p. 705, December, 1912.
Fuel Resources of California.
Requa, M. L., Western Engineering, Vol. 1, p. 60, April, 1912.

Geology and Technology of the California Oil Fields.
Arnold, R. and Garfias, V. R., American Institute Mining Engineers, Bulletin 87, March, 1914.
Petroleum Industry of California (Notes).
Wolf, J. H. G., American Society Civil Engineers, April, 1914.
Fuel Resources of California.
Requa, M. L., Bradley, F. W., Stalder, W., Transactions, Commonwealth Club of San Francisco, 1912.

Cementing.

Cementing Off Water in California Oil Fields.
Hager, D., Western Engineering, Vol. 1, p. 534, October, 1912.
Cementing Oil Wells as a Problem in Cement Chemistry.
Huber, F. W., Western Engineering, Vol. 4, p. 341, May, 1914.
Kammerer Method of Cementing Off Water in Drilling Oil Wells.
Phelps, Robert W., Western Engineering, Vol. 3, p. 360, November, 1913.
Cementing Off Water in California Oil Fields.
Stroud, B. K., Western Engineering, Vol. 2, p. 203, March, 1913.
Method of Cementing Off Water in Drilling Wells.
Paine, P. M., Western Engineering, Vol. 2, p. 445, June, 1913.
Cementing Process.
Arnold, R. and Garfias, V. R., U. S. Bureau of Mines, Technical Paper, 32.

Coalinga District. See Fresno County.

Colusa County.

Petroleum in Colusa County.
Fairbanks, H. W., California State Mineralogist's Report, 11, pp. 54-75, 1893
Goodyear, W. A., California State Mineralogist's Report, 8, pp. 158-9, 1888.
California State Mineralogist's Report, 10, pp. 153-164, 1890.
California State Mineralogist's Report, 13, p. 570, 1896.
Watts, W. L., California State Mining Bureau, Bulletin 3, p. 6, 1896.
Watts, W. L., California State Mining Bureau, Bulletin 19, pp. 159-161, 1900.

Combustion. See also Fire.

Combustion of California Crude Oil.
Glas, Will M., Western Engineering, Vol. 1, p. 723, December, 1912.
Oil Fuel.
Kermode, J. J., Western Engineering, Vol. 1, p. 726, December, 1912.
Atomizing California Fuel Oil.
Goeriz, O. C., Western Engineering, Vol. 1, p. 627, November, 1912.

Compressor Plant. See also Gasoline.

Air Lift Pumping of Fluids.
Rix, E. A., Oil Industry, Vol. 3, No. 6, 1910.

Contra Costa County.

Miner Ranch.
Arnold, Ralph, U. S. Geological Survey, Bulletin 340 F, 1908.
Petroleum in Contra Costa County.
Goodyear, W. A., California State Mineralogist's Report, 10, p. 165, 1890.
Petroleum in Contra Costa County.
Watts, W. L., California State Mining Bureau Bulletin 19, p. 156-7, 1900.
Petroleum in Contra Costa County.
California State Mineralogist's Report, 13, p. 571, 1896.

Coyote Hills Field. See Los Angeles County.

Diesel Engine. See under Pumping.

Drilling. See, also, Production.

New Method of Rotary Well Drilling.
Parsons, A. T., Western Engineering, Vol. 1, p. 450-3, September, 1912.

- Rotary Well Drilling.
  - Rea, Colin Campbell. Western Engineering, Vol. 1, pp. 202-6, June, 1912.
- Elements of Oil Well Drilling.
  - Hager, D., Western Engineering, Vol. 2, p. 447, June, 1913.
- Speed Reducing Gear for Electric Oil Well Drilling.
  - Williamson, F. A., Western Engineering, Vol. 2, p. 197, March, 1913.
- Drilling and Pumping Oil Wells by Electricity.
  - Taylor, W. G., General Electric Review, Vol. XVII, p. 622, 1914.
- Drilling in California.
  - Jewell, W. R., Mining and Scientific Press, Vol. 101, p. 775, 1910.
  - Jewell, W. R., Mining and Scientific Press, Vol. 103, p. 44, 1911.
- Drilling Boilers.
  - Menzin, A. L., Journal Electric Power and Gas, Vol. 28, p. 51, 1912.
- Mud-Laden Fluid Applied to Drilling.
  - Pollard, J. A. and Heggem, A. G., U. S. Bureau of Mines, Technical Paper 66. 1913.
- Mud-Laden Fluid in Oklahoma Well Drilling.
  - U. S. Bureau of Mines, Technical Paper 68.
- Well Boring for Water, Brine and Oil.
  - Isler, C., Sponn & Co., London, 269 pp.
- Well Drilling Methods.
  - Bowman, I., U. S. Geological Survey, W. S. Paper 257, 1911.

Fire.

- Extinguishing Fires in Oils and Volatile Liquids.
  - Barrier, E. A., Western Engineering, Vol. 3, p. 476, December, 1913.
- California Methods of Preventing and Extinguishing Oil Fire.
  - Bowie, C. P., Western Engineering, Vol. 4, p. 105, February, 1914.
- Unusual Cause of Oil Tank Fire.
  - Stroud, B. K., Western Engineering, Vol. 1, p. 625, November, 1912.

Fresno County.

- Geology of the Coalinga District.
  - Arnold, R., and Anderson, R., U. S. Geological Survey, B. 357, 1908.
  - Arnold, R., and Anderson, R., U. S. Geological Survey, B. 398, 1910.
  - Eldridge, G. H., U. S. Geological Survey, B. 213, pp. 306-8, 1902.
- Geology of the Cantua-Panoche District.
  - Anderson, Robert, U. S. Geological Survey, B. 431a, 1911.
- Water Conditions in Coalinga District.
  - McLaughlin, R. P., Mining and Scientific Press, Vol. 101, p. 305, 1910.
- Coalinga Oil Measures.
  - McLaughlin, R. P., Mining and Scientific Press, Vol. 98, p. 548, 1909.
  - Forstner, William. Mining and Scientific Press, Vol. 98, p. 389, 1909.
- Coalinga Field.
  - Prutzman, P. W., California State Mining Bureau, Bulletin 32, p. 43, 1904.
- Fresno County.
  - Watts, W. L., California State Mining Bureau, Bulletin 19, pp. 136-142, 1900.
  - California State Mineralogist's Report, 10, p. 189, 1890.
  - California State Mineralogist's Report, 12, p. 352, 1894.
  - California State Mineralogist's Report, 13, p. 571, 1896.
- Geology and Oil Prospects in Waltham, Priest, Bitterwater, and Peachtree Valleys, California.
  - Pack, R. W., and English, W. A., U. S. Geological Survey, Bulletin 581-D, 1914.

Fullerton Field. See Los Angeles County.

Gas.

California Natural Gas.
    Cross, G. N., Western Engineering, Vol. 1, p. 555, October, 1912.
Compressor Plant of the Southern California Gas Company.
    Hutchinson, C. T.; Western Engineering, Vol. 4, p. 344, May, 1914.
Gas in Contra Costa County.
    California State Mineralogist's Report, 8, p. 161, 1888.
Gas in California.
    California State Mineralogist's Report, 7, pp. 181-191, 1888.
    California State Mineralogist's Report, 10, pp. 601-603, 1890.
    California State Mining Bureau, Bulletin 3, 1894.
Gas Analyses.
    American Institute Mining Engineers, Vol. 15, pp. 529-31.
    American Institute Mining Engineers, Vol. 16, pp. 922-952.
    American Institute Mining Engineers, Vol. 35, pp. 740-742.
    American Institute Mining Engineers, Vol. 42, pp. 409-435.
Waste in Production of Gas.
    Arnold, R., Clapp, F. G., U. S. Bureau of Mines, Technical Paper, 38.
Prevention of Waste, California Gas.
    Arnold, R., Garfias, V. R., U. S. Bureau of Mines, Technical Paper. 42.

Gasoline.

Manufacture of Gasoline from Natural Gas.
    Hutchinson, Charles T., Western Engineering, Vol. 2, p. 363, May, 1913.
Refrigeration Process for the Manufacture of Gasoline from Casing-Head Gas.
    Hutchinson, Charles T., Western Engineering, Vol. 4, p. 116, February, 1914.
Examination of Natural Gas for the Production of Gasoline.
    Merriam, E. S., and Birchby, J. A., Western Engineering, Vol. 3, p. 374, November, 1913.
The Patent Processes for Making Casing-Head Gasoline.
    Chute, H. O., Western Engineering, Vol. 4, p. 304, April, 1914.
Production of Gasoline from Natural Gas.
    Hirshfield, C. F., Western Engineering, Vol. 1, p. 557, October, 1912.

Geology. See also under the different oil fields.

Graphical Studies of Oil Formation.
    Parsons, A. T., Western Engineering, Vol. 4. p. 278, April, 1914.
Derivation of Oil Well Logs.
    Phelps, Robert W., Western Engineering, Vol. 2, p. 281, April, 1913.
Effects of Faulting in Oil Fields.
    Hager, D., Western Engineering, Vol. 4, p. 442, June, 1914.
Anticlinal Dome Structure in California Oil Fields.
    Hager, D., Western Engineering, Vol. 3, p. 196, September, 1913, and Vol. 4, p. 28. January, 1914.
Mojave Desert Stratigraphy.
    Baker, C. L., University of California Bulletin, Department of Geology, Vol. 6, No. 15, pp. 333-383, 1911.
Conditions of Oil Accumulation.
    Day, David T., American Institute Mining Engineers, Vol. 41, pp. 219-224.
Geology of the San Francisco Peninsula.
    Fairbanks, H. W., Journal of Geology, Vol. 5, pp. 63-76, 1897.
    Lawson, A. C., U. S. Geological Survey, Vol. 15, pp. 399-476, 1895.
Stratigraphy in the Coast Ranges.
    Fairbanks, H. W., Journal of Geology, Vol. 11, pp. 415-433, 1895.
Geologic Record of California.
    Smith, James P., Journal of Geology, Vol. 18, pp. 216-227, 1910.
The Genesis of Petroleum and Asphalt in California.
    Cooper, A. S., California State Mining Bureau Bulletin 16, 1899.

Geologic Occurrences of Oil.
American Institute of Mining Engineers, Vol. 33, pp. 364-368.
American Institute of Mining Engineers, Vol. 35, pp. 288-297.
Capacity of Oil Sands.
American Institute of Mining Engineers, Vol. 16, pp. 913-915.
Oxidation of Petroleum.
American Institute of Mining Engineers, Vol. 16, p. 448.
Use of Graphic Models in Showing the Geology of Oil and Gas Pools.
Huntley, L. G., Western Engineering, August, 1914.
Causes of Collapsed Casing.
Hager, Dorsey, Western Engineering, September, 1914.
Unconformities and Overlap and their Effects on Oil Fields.
Hager, D., Western Engineering, October, 1914.
Geology and Technology of the California Oil Fields.
Arnold, R., and Garfias, V. R., American Institute of Mining Engineers, Bulletin 87, pp. 382-469, 1914.
Oil Finding.
Cunningham-Craig, E. H., Longmans, Green & Co., N. Y., 1912, 195 pp.
Elements of Geology.
Le Conte, J., D. Appleton & Co., N. Y., 1910, 665 pp.
Textbook of Geology.
Park, J., J. B. Lippincott Company, Philadelphia, 1914, 598 pp.

Humboldt County.

Petroleum in Humboldt County.
Anderson, F. M., California State Mining Bureau Bulletin 19, pp. 161-6, 1900.
California State Mineralogist's Report, 8, p. 216, 1888.
California State Mineralogist's Report, 10, p. 207, 1890.
California State Mineralogist's Report, 11, pp. 227-232, 1893.

Kern County.

Whitney, J. D., Geological Survey of California, Geology 1, pp. 199-202, 1865.
Watts, W. L., California State Mining Bureau Bulletin 3, pp. 20-38, 1894.
Watts, W. L., California State Mining Bureau Bulletin 19, pp. 106-131, 1900.
Goodyear, W. A., California State Mineralogist's Report, 7 and 8, pp. 67 and 309, 1888.
California State Mineralogist's Report, 11, pp. 233-238, 1893.
California State Mineralogist's Report, 12, pp. 353, 1894.
McKittrick-Sunset Oil District.
Arnold, R., and Johnson, H. R., U. S. Geological Survey Bulletin 406, 1910.
Eldridge, G. H., U. S. Geological Survey Bulletin 213, pp. 308-312, 1902.
South End of San Joaquin Valley.
Anderson, Robert, U. S. Geological Survey Bulletin 471-A, 1912.
Kern River Field.
Anderson, F. M., California Academy of Sciences, Vol. 3, pp. 73-146, 1911.
South Midway.
Forstner, William, Economic Geology, Vol. 6, No. 2, pp. 138-155.
Kern River, Midway, McKittrick and Sunset Fields.
Prutzman, P. W., California State Mining Bureau, Bulletin 32, pp. 35-41, 1904.
Lost Hills and Belridge Oil Fields.
McLaughlin, R. P., Western Engineering, Vol. 1, p. 546, October, 1912.
Geology of Midway-Sunset Oil Field.
McLaughlin, R. P., Western Engineering, Vol. 1, pp. 365-8, August, 1912.

Kern River Field. See Kern County.

Kings County.

Petroleum in Kings County.
Watts, W. L., California State Mining Bureau, Bulletin 3, pp. 53-55, 1894.
Watts, W. L., California State Mining Bureau, Bulletin 19, pp. 131-136, 1900.
Gas in Kings County.
California State Mineralogist's Report, 13, p. 567, 1896.

La Habra Field. See Los Angeles County.

J. R. DORRA
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Lake County.

Gas in Lake County.
  California State Mineralogist's Report, 8, p. 326, 1888.

Legislation.

Legislation on Petroleum Lands.
  Forstner, William, Mining and Scientific Press, Vol. 103, p. 316, 1911.
  Mining and Scientific Press, Vol. 81, p. 370, 1900.

Leases.
  Mining and Scientific Press, Vol. 84, p. 155, 1902.

Lompoc Field. See Santa Barbara County.

Los Angeles County.

Petroleum in Los Angeles County.
  Eldridge, G. H., U. S. Geological Survey, Bulletin 213, pp. 318-321, 1902.
  Arnold, R., U. S. Geological Survey, Bulletin 285, g. 1906.
  Eldridge, G. H., and Arnold, R., U. S. Geological Survey, Bulletin 309, 1907.
  Prutzman, P. W., California State Mining Bureau, Bulletin 63, pp. 156-334, 1913.
  Prutzman, P. W., California State Mining Bureau, Bulletin 32, pp. 22-30, 1904.
  Preston, E. B., California State Mineralogist's Report, 9, pp. 189-210, 1890.
  Watts, W. L., California State Mining Bureau, Bulletin 11, 1896.
  Watts, W. L., California State Mining Bureau, Bulletin 19, 1900.
  California State Mineralogist's Report, 13, p. 572, 1896.

Los Angeles Field. See Los Angeles County.
Lost Hills Field. See Kern County.

Marin County.

Gas in Marin County.
  California State Mineralogist's Report, 13, p. 567, 1896.

Cross Section in Marin County.
  Osmont, V. C., University of California, Department of Geology, Vol. 4, No. 3, 1904.

Geology of Point Reyes.
  Anderson, F. M., University of California, Department of Geology, Vol. 2, No. 5, pp. 119-153, 1899.

McKittrick Field. See Kern County.

Mendocino County.

Petroleum in Mendocino County.
  California State Mining Bureau, Bulletin 19, p. 158, 1900.
  California State Mineralogist's Report, 8, p. 349, 1888.
  California State Mineralogist's Report, 10, p. 314, 1890.
  California State Mineralogist's Report, 13, p. 36, 1896.

Midway Field. See Kern County.

Monterey County.

Asphalt in Monterey County.
  California State Mineralogist's Report, 13, p. 36, 1896.

Bituminous Rock.
  California State Mineralogist's Report, 11, p. 259, 1892.

Cholame Valley Well in Monterey County.
  California State Mineralogist's Report, 12, p. 356, 1894.

Geology of Monterey County.
  Fairbanks, H. W., California State Mineralogist's Report, 12, p. 493, 1894.

Geology of Salinas Valley.
  Nutter, E. H., Journal of Geology, Vol. 9, pp. 330-6, 1901.
  Fairbanks, H. W., California State Mining Bureau, Bulletin 19, pp. 143-6, 1900.

Oil Yielding Formations and Wells.
California State Mining Bureau, Bulletin 19, pp. 143-6, 1900, H. W. Fairbanks.
Petroleum in Monterey County.
California State Mineralogist's Report, 8, p. 404, 1888.
Wells of Salinas Valley.
Hamlin, Homer, U. S. Geological Survey, W. S. Paper 89, pp. 13-19, 1904.
Geology and Oil Prospects in Waltham, Priest, Bitterwater, and Peachtree Valleys, California.
Pack, R. W., and English, W. A., U. S. Geological Survey, Bulletin 581-D, 1914.

Napa County.

Petroleum in Napa County.
California State Mining Bureau, Bulletin 19, p. 166, 1900.
California State Mineralogist's Report, 13, p. 582, 1896.
Cross Section in Napa County.
Osmont, V. C., University of California, Bulletin, Department of Geology, Vol. 4, No. 3, 1904.

Orange County.

Petroleum in Orange County.
Watts, W. L., California State Mining Bureau, Bulletin 19, 1900.
Prutzman, P. W., California State Mining Bureau, Bulletin 32, p. 20. 1904.
Prutzman, P. W., California State Mining Bureau, Bulletin 63, p. 334. 1913.

Production.

Possible Causes of Well Decline.
Huntley, L. G., U. S. Bureau of Mines, Technical Paper 51.
Oil Recovery at California Wells.
Arnold, R., and Garfias, V. R., U. S. Bureau of Mines, Technical Paper 72, 1914.
Oil Production Methods.
Paine, P. M., and Stroud, B. K., Western Engineering Publishing Company, San Francisco, 1913, p. 240.
Petroleum and its Products.
Redwood, B., and Holloway, G. T., Charles Griffin & Co., Ltd., London, 1913, p. 1198.
Petroleum and its Products.
Peckham, S. F., U. S. Census Office, 1885, p. 317.
Treatise on Petroleum.
Redwood, B., Chas Griffin & Co., London, 1913, three volumes.
Petroleum Mining and Oil Field Development.
Thompson, A. Beeby, p. 384.
Petroleum Year Book, 1914.
North, S. H. Wilkinson Brothers, Ltd., London, p. 101.
Estimating Productive Capacity of Oil Lands.
McLaughlin, R. P., Western Engineering, July, 1914.

Pumping.

Cost of Pumping Oil by Electricity in the California Oil Fields.
Gassaway, S. G., Western Engineering, Vol. 3, p. 273, October, 1913.
Oil Well Pumping Methods.
Cox, Thomas, Western Engineering, Vol. 1, pp. 93-6, May, 1912.
Pumping by Compressed Air.
Abrams, H. T., Western Engineering, Vol. 1, p. 234, June, 1912.
Oil Pumping Practice at Bakersfield.
Hutchinson, Charles T., Western Engineering, Vol. 1, pp. 349-358, August, 1912.
Oil Well Compressed Air Pumping Systems.
Ivens, E. M., Western Engineering, Vol. 1, p. 466, September, 1912.
Electric Motors for Oil Field Service.
Somers, L. A., Western Engineering, Vol. 2, p. 107, February, 1913.

Electrifying the Oil Fields.
Wishon, A. E., Western Engineering, Vol. 2, p. 35, January, 1913.
Electricity in the Oil Fields.
Russel, H. A., Western Engineering, Vol. 2, p. 269, April, 1913.
The Stationary Diesel Engine.
Haas, Herbert, Western Engineering, Vol. 2, p. 209, March, 1913.
Cost of Generating Power with Diesel Oil Engines.
Kribs, G., Western Engineering, Vol. 3, p. 215, September, 1913.
Drilling and Pumping Oil Wells by Electricity.
Taylor, W. G., General Electric Review, Vol. XVII, p. 622, 1914.
Taylor, W. G., Western Engineering, August, 1914.
Flow of Oil in Pipes (Notes).
Dyer, E. I., Journal of American Society Mechanical Engineers, July, 1914.
Well Pumping by Electricity.
Van Norden, R. W., Journal of Electric Power and Gas, Vol. 28, p. 423, 1912.
Oil Pipe Lines (Hydraulic Principles).
Cooper, A. S., Mining and Scientific Press, Vol. 82, p. 123, 1901.

Physical and Chemical Properties.

San Joaquin Valley Oils.
Allen, I. C., and Jacobs, W. A., U. S. Bureau of Mines, Bulletin 19.
California Oils.
Allen, I. C., U. S. Bureau of Mines, Technical Paper 74.
Determination of Water Content.
Allen, I. C., and Jacobs, W. A., U. S. Bureau of Mines, Technical Paper 25.
Determination of Sulphur Content.
Allen, I. C., and Robertson, I. W., U. S. Bureau of Mines, Technical Paper 26.
Preparation of Specifications.
Allen, I. C., U. S. Bureau of Mines, Technical Paper 36.
Flash Point of Oils.
Allen, I. C., and Crossfield, A. S., U. S. Bureau of Mines, Technical Paper 49.
Gravity of Crude Oils.
Kritzer, Wm. H., Western Engineering, Vol. 2, p. 290, April, 1913.
Short Handbook of Oil Anaylsis.
Gill, A. H., J. B. Lippincott Co., Philadelphia, 1911, p. 180.
Chemistry of the Oil Industries.
Southcombe, J. E., p. 209.
Chemical Metallurgical Handbook.
Cremer, J. H., and Bicknell, G. A., J. B. Savage, Cleveland, Ohio, 1903, pp. 406.

Refining.

Refining Petroleum from California Oils.
Stabler, L. J., California Derrick, Vol. 6, January, 1914.
Stabler, L. J., California Derrick, Vol. 6, February, 1914.
Refining Petroleum Crude Oils.
Howard, J. C., Western Engineering, Vol. 2, p. 223, 1913.
Manufacture of Petroleum Products.
Robinson, F. C., Western Engineering, Vol. 3, p. 47, 1913.

Sacramento County.

Gas in Sacramento County.
California State Mineralogist's Report, 13, p. 567, 1896.

Salt Lake Field. See Los Angeles County.

Sampling.

Shipping and Sampling Crude Oil.
Paine, P. M., Western Engineering, Vol. 3, p. 22, July, 1913.

San Benito County.

Geology of San Benito County.
Fairbanks, H. W., California State Mineralogist's Report, 12, p. 493.
Oil Companies of San Benito County.
Fairbanks, H. W., California State Mining Bureau, Bulletin 19, pp. 148-150, 1900.
Preliminary Report on the Geology and Oil Prospects of Cantua-Panoche Oil District.
Anderson, R., U. S. Geological Survey, Bulletin 431a, pp. 58-87, 1911.
San Benito County.
Becker, G. F., U. S. Geological Survey, Monograph 13, 1888.
San Carlos Well.
Mining and Scientific Press, Vol. 64, p. 352, 1892.
San Carlos Well.
California State Mineralogist's Report, 12, p. 356, 1894.
Geology and Oil Prospects in Waltham, Priest, Bitterwater, and Peachtree Valleys, California.
Pack, R. W., and English, W. A., U. S. Geological Survey, Bulletin 581-D, 1914.

San Bernardino County.

Petroleum in San Bernardino County.
Prutzman, P. W., California State Mining Bureau, Bulletin 63, p. 337, 1913.
Barstow-Kramer Region.
Pack, R. W., U. S. Geological Survey, Bulletin 541-E, 1913.

San Diego County.

Petroleum in San Diego County.
Hanks, H. G., California State Mineralogist's Report, 6, pp. 80-90, 1887.
Petroleum in San Diego County.
Goodyear, W. A., California State Mineralogist's Report, 8, pp. 516-528. 1888.
Petroleum in San Diego County.
Watts, W. L., California State Mining Bureau, Bulletin 19, p. 61, 1900.

San Joaquin County.

Petroleum in San Joaquin County.
California State Mineralogist's Report, 8, pp. 560-1, 1888.
California State Mineralogist's Report, 13, p. 567, 1896.

San Luis Obispo County.

Abandoned Well in Santa Lucia Mountains.
California State Mineralogist's Report, 12, p. 356, 1894.
Bituminous Mines.
California State Mineralogist's Report, 13, p. 37, 1896.
Bituminous Rock Deposits.
Fairbanks, H. W., Mining and Scientific Press, Vol. 76, p. 661, 1898.
Geology of San Luis Obispo County.
Fairbanks, H. W., California State Mineralogist's Report, Vol. 12, p. 493, 1894.
Oil Yielding Formations and Wells.
Fairbanks, H. W., California State Mining Bureau, Bulletin 19, pp. 146-8, 1900.
Petroleum.
Mining and Scientific Press, Vol. 64, p. 131, 1892.
Petroleum.
Mining and Scientific Press, Vol. 57, p. 91, 1888.
Petroleum in San Luis Obispo County.
California State Mineralogist's Report, 8, p. 530, 1888.

San Mateo County.

Petroleum in San Mateo County.
  Watts, W. L., California State Mining Bureau, Bulletin 19, pp. 154-6. 1900.
Petroleum in San Mateo County.
  California State Mineralogist's Report, 8, p. 534, 1888.
  California State Mineralogist's Report, 10, p. 586, 1890.
Petroleum in Santa Cruz Quadrangle, San Mateo County.
  U. S. Geological Survey, Folio 163, p. 11, 1909.

Santa Barbara County.

Geology of the Santa Maria District.
  Arnold, R., and Anderson, R., U. S. Geological Survey, Bulletin 317, 1907.
  Arnold, R., and Anderson, R., U. S. Geological Survey, Bulletin 323, 1907.
Geology of the Summerland District.
  Arnold, R., U. S. Geological Survey, Bulletin 321, 1907.
Geology of the Graciosa District.
  Eldridge, G. H., U. S. Geological Survey, Bulletin 213, p. 313, 1902.
Petroleum in Santa Barbara County.
  Watts, W. L., California State Mining Bureau, Bulletin 11, 1896.
  Watts, W. L., California State Mining Bureau, Bulletin 19, pp. 102-5, 1900.
  Prutzman, P. W., California State Mining Bureau, Bulletin 32, pp. 32-45. 1904.
  Prutzman, P. W., California State Mining Bureau, Bulletin 63. pp. 339-416, 1913.
  California State Mineralogist's Report, 8, pp. 534-538, 1888.
  California State Mineralogist's Report, 12, pp. 357-493, 1894.
  California State Mineralogist's Report, 13, pp. 38-42, 1896.
Progress in the Cat Canyon Field.
  Smith, H. D., Western Engineering, Vol. 3, p. 26, Oct. 1913.

Santa Clara County.

Geology of the Sargent Oil Fields.
  Jones, W. F., University of California, Department of Geology, Bulletin 6. No. 3, pp. 55-78, 1911.
  Watts, W. L., California State Mining Bureau, Bulletin 19, pp. 151-4, 1900.
  Weber, A. H., California State Mineralogist's Report, 8, p. 547, 1888.
  California State Mineralogist's Report, 9, p. 54, 1889.
  California State Mineralogist's Report, 10, p. 606, 1890.
  California State Mineralogist's Report, 13, pp. 43, 569, 585, 1896.

Santa Cruz County.

Geology of the Santa Cruz Quadrangle.
  Branner, J. C., Newsom, J. F., Arnold, R., U. S. Geological Survey, Geological Folio 163.
  Petroleum in Santa Cruz County.
  California State Mineralogist's Report, 8, p. 550, 1888.
  California State Mineraogist's Report, 10, p. 622, 1890.
  California State Mineralogist's Report, 13, p. 585, 1896.

Santa Maria Field. See Santa Barbara County.

Shasta County.

Petroleum in Shasta County.
  California State Mineralogist's Report, 11, p. 31, 1892.

Shipping. See Sampling and Transportation.

Solano County.

Gas in Solano County.
  California State Mineralogist's Report, 13, p. 569, 1896.

Sonoma County.

Petroleum in Sonoma County.
Watts, W. L., California State Mineralogist's Report, 11, pp. 453-463, 1893.
Geologic Cross Section in Sonoma County.
Osmont, V. C., University of California, Geological Department, Bulletin IV, No. 3, 1904.

Storage.

Reinforced Concrete Oil Tank.
Mayberry, E. L., Western Engineering, Vol. 3, p. 37, July, 1913.
Handbook of Petroleum.
Thompson, J. H., and Redwood, B., C. Griffin & Co., London, p. 344.

Sunset Field. See Kern County.

Tanks. See Storage.

Transportation.

Report of the Commissioner of Corporations on the Transportation of Petroleum.
Department of Commerce and Labor, Washington, D. C., May, 1906.

Tulare County.

Gas in Tulare County.
California State Mineralogist's Report, 13, p. 569, 1896.

Uses.

Comparisons of Oil and Coal.
Chevalier, R. F., Journal of Electric Power and Gas, Vols. 24 and 25.
Developments of Oil Gas in California.
Jones, E. C., Journal of Electric Power and Gas, Vol. 24, p. 492, 1910.
Liquified Products of Natural Gas.
Allen, I. C., Burrell, G. A., U. S. Bureau of Mines, Technical Paper 10.
Heavy Oil for Internal Combustion Engines.
Allen, I. C., U. S. Bureau of Mines, Technical Paper 36.
Liquid Fuel and its Apparatus.
Booth, W. H., E. P. Dutton & Co., New York, pp. 308.
Oil Fuel: Its Supply, Composition and Application.
North, S. H., and Butler, E., Chas. Griffin & Co., London, 1911, pp. 238.
Butler, E., J. B. Lippincott Co., Philadelphia, 1914, pp. 328.
Producing Gas from Crude Oil.
Jones, E. C., Journal of Electric Power and Gas, Vol. 26, p. 269, 1911.
Oil Fuel for Steam Boilers.
Strohm, R. T., McGraw Hill Co., New York, 1914, pp. 144.
Gasification of Petroleum.
Percy, E. M., Journal of Electric Power and Gas, Vol. 26, p. 153, 1911.
Industrial Applications of Oil Burning.
Percy, E. M., Journal of Electric Power and Gas, Vol. 28, p. 8, 1912.
Oil in Smelting.
Von der Ropp, A., Mining and Scientific Press, 1902.
Locomotive Practice in Use of Fuel Oil.
Stillman, Howard, Journal of Electric Power and Gas, Vol. 26, p. 313, 1911.
Comparative Evaporation Values of Coal and Oil.
Wieland, C. T., Journal of Electricity Power and Gas, Vol. 26, p. 240. 1911.
Fuel: Gaseous, Liquid and Solid.
Coste, J. H., and Andrews, E. R., J. B. Lippincott Co., Philadelphia. 1914, p. 278.
Specifications for Purchase.
Allen, I. C., U. S. Bureau of Mines, Technical Paper 3.

Valuation.

Valuation of Oil Lands.
Forstner, Wm., Mining and Scientific Press, Vol. 103, p. 578, 1911.

Ventura County.

Geology of the Santa Clara Valley Region.
  Eldridge, G. H., U. S. Geological Survey, Bulletin 213, pp. 315-318, 1902.
  Eldridge, G. H., and Arnold, R., U. S. Geological Survey, Bulletin 309, 1907.
Structural Geology South of the Santa Susana District.
  Waring, C. A., Western Engineering, Vol. 3, p. 470, Dec. 1913.
Geologic Notes on the Santa Susana District.
  Johnson, H. R., Western Engineering, Vol. 2, p. 383, May, 1913.
Petroleum in Ventura County.
  Peckham, S. F., Geological Survey of California, Economic Geology, Vol. 2, 1866.
  California State Mineralogist's Report, 8, pp. 679-690, 1888.
  California State Mineralogist's Report, 10, pp. 758-772, 1890.
  Fairbanks, H. W., California State Mineralogist's Report, 12, pp. 493-526, 1894.
California State Mineralogist's Report, 13, pp. 585-593, 1896.
  California State Mining Bureau, Bulletin 11, 1896.
  California State Mining Bureau, Bulletin 19, pp. 83-101, 1900.
  Prutzman, P. W., California State Mining Bureau, Bulletin 32, p. 47, 1904.
  Prutzman, P. W., California State Mining Bureau, Bulletin 63, pp. 21-156, 1913.

Water.

Dehydration of Crude Petroleum.
  Beazley, A. T., Western Engineering, Vol. 1, pp. 56-60, April, 1912.
Menace of Water in the Oil Fields.
  Storms, W. H., and Prutzman, P. W., Western Engineering, Vol. 1, pp. 106-114, May, 1912.
Water Emulsions in Crude Petroleum.
  Wright, S. C., Western Engineering, Vol. 1, pp. 307-210, June, 1912.
Electric Separation of Water.
  Cottrell, F. G., American Institute of Mining Engineers, Vol. 43, p. 514.
Water in Oil Wells.
  McLaughlin, R. P., Mining and Scientific Press, Vol. 102, p. 295, 1911.

Whittier Field. See Los Angeles County.

Yolo County.

Geologic Cross Section in Yolo County.
  Osmont, V. C., University of California, Department of Geology, Vol. 4, No. 3, 1904.

INDEX.

PAGE.
Abbey, A. 14
Agency 16, 37, 38, 39
Air Compressors 212, 214
Alameda County—
  Bibliography 497
  Geology 439
Amalgamated Oil Co. 29, 30, 42, 43, 45, 489
  Pipe lines 94
Analysis—
  Gas, Coalinga 163
  Gas, Midway 250
  Humboldt County Oil 452
  Water, Coalinga 160
Anderson, F. M. 195
Anticline, definition 22
Appendix 475
Arroyo Grande—
  Geology 430
  Statistics 433, 434
Associated Oil Co. 14, 16, 29, 30, 40, 41, 42, 293, 484
  Pipe Lines 93
Associated Pipe Line Co. 93, 484
Automobile Trucks 158
Bard Oil and Asphalt Co. 490
Belridge Field 302
Beverly Hills, Geology 357
Bibliography 497
Boiler Water, treatment 160
Bottom Water, definition 23
Boulders, definition 23
Bradley, W. W. 459
Bradley District, Geology 435
Brea Canyon, Geology 359
Break, definition 22
Buena Vista Hills 219, 231, 248
Burrel Point, Geology 364
Butte County, oil possibilities 440
Cable, used in drilling 153
Capital invested 9
Casing—
  Amount used
  Coalinga 151
  Collapsing strength 237
  Cost 239
  Midway 238
  Santa Maria 415
  Salt Lake 348
Cementing—
  Bibliography 498
  Wells 154
Central Oil Co. 490
Chico formation 351, 382
Chino Region, Geology 364
Circulating System of Drilling 364
Coal, displaced by oil 83
Coalinga—
  Companies 136, 137, 138, 139
  District 119
  Geology 131
  Monthly Statistics 127, 128, 129
Coefficient of Expansion of Petroleum 79
Columbia Oil Producing Co. 489

PAGE.

- Colusa County—
  - Bibliography 498
  - Geology and Oil Possibilities 441
- Combustion of Oil, Bibliography 498
- Commercial Uses of Oil 84
- Companies Operating,
  - Coalinga 136, 137, 138, 139
  - Kern River 210
  - Los Angeles 344
  - Lost Hills and Belridge 307
  - McKittrick 300
  - Midway 232
  - Newhall 380
  - Salt Lake 345
  - Santa Maria 413
  - Summerland 417
  - Sunset 264
  - Ventura 379
  - Whittier-Fullerton 345
- Compressed Air 213, 215
- Compressors, Gas 254
- Conglomerate, definition 23
- Contra Costa County—
  - Bibliography 498
  - Geology and Oil Possibilities 442
- Control of Production 29, 30
- Cost—
  - Air Compressors 213
  - Casing, Salt Lake 348
  - Cementing 154
  - Drilling 26, 212, 239, 414
  - Drilling, Coalinga 141, 147, 148, 149, 152, 153
  - Drilling, Puente and Coyote 349
  - Drilling, Salt Lake 347
  - Electric Operations 164
  - Electric Power 242, 245
  - Gas Engines and Operations 163
  - Gas Power 242
  - Hauling 157
  - Oil Production 155
  - Operating 9
  - Operating Wells 25
  - Production, Los Angeles vicinity 346
  - Pumping 26, 158, 212, 242, 301
  - Pumping by Gas 247
  - Pumping by Steam 247
  - Pumping, Santa Maria 416
  - Reservoirs 102
  - Steam Plant 161
  - Tanks 104
  - Well Repair 27, 166, 242, 301
- Coyote Hills—
  - Bibliography 498
  - Geology 362
- Cretaceous Formation 421
- Cretaceous Rocks 131
- Dallas, R. W. 169
- Decline of Gas Wells 252
- Decline of Wells 13, 14
  - Coalinga 188
  - Midway 266
  - Sunset 266
  - Ventura 371
  - Whittier-Fullerton 315
- Development, By Marketers 15
- Development (See History of Development).

PAGE.
Development, Lost Hills, Belridge 305
Devil's Den Field 302
Diagrams, production 267
Diagrams of Production, Explanation 57
Diesel Engines 85
Diesel Engines, Bibliography 498
Dip, Definition 23
Directory of Companies—
  Coalinga 136
  Kern River 210
  Los Angeles 344
  Lost Hills and Belridge 317
  McKittrick 300
  Midway 232
  Newhall 380
  Salt Lake 345
  Santa Maria 413
  Summerland 417
  Sunset 264
  Ventura 379
  Whittier-Fullerton 345
Dividends paid 9
Drilling—
  Bibliography 498
  Cable 153
  Circulation 153
  Cost 414
  Fuel 153
  Kern River 212
  Methods and Cost, Coalinga 141
  Midway 236
Power—
  Puente, Coyote 349
  Rate 149
  Rate, Salt Lake 348
  Salt Lake 347
  Santa Maria 414
  Time 238
East Side Field, Coalinga 122
Edna District, geology 430
Eel River Valley, geology and oil possibilities 455
Electricity in Pumping 164
Electricity vs. Gas 242
Elk Hills 218
Etchegoin Formation 134, 228, 292, 303, 423
Evaporation, Loss of Oil 60–76
Exports of Oil 95, 96, 97
Fault, definition 22
Fernando Formation 353, 387
Financial Results—
  Coalinga, 1913 130
  Kern River, 1913 208
  Los Angeles and Orange Counties, 1913 325
  McKittrick, 1913 299
  Midway, 1913 225
  Santa Maria, Lompoc and Summerland, 1913 414
  Sunset, 1913 259
  Ventura, 1913 378
Financial Review by fields 9, 10, 11
Fire, Oil, Bibliography 505
Formation, definition 385
Fuel Oil, in drilling 153
Fullerton-Brea Canyon Field 311
Fullerton-Brea Canyon, Monthly Statistics 340

PAGE.

Fullerton Field—
  Bibliography ---- 499
  Geology ---- 360
Franciscan Formation ---- 131
Franciscan Series ---- 421, 447
Fresno County—
  Bibliography ---- 499
  Gas Statistics ---- 118
  Oil Statistics ---- 124
Future, Belridge ---- 313
Future Developments, near Los Angeles. ---- 315
Future—
  Humboldt County ---- 455
  Kern River ---- 204
  Lost Hills ---- 303
  McKittrick ---- 293
  Midway ---- 221
  Monterey County ---- 438
  Salt Lake ---- 315
  San Benito County ---- 438
  San Luis Obispo County ---- 438
  Santa Maria ---- 405
  Ventura ---- 395
  Whittier-Fullerton ---- 315
Garrizo District, Geology ---- 429
Gas—
  Analysis, Coalinga ---- 163
  Analysis, Midway ---- 250
  Bibliography ---- 500
  Manufactured from Oil ---- 84
  Natural, Midway ---- 248
  Pipe Lines ---- 252, 255
  Power for Operating Wells ---- 162
  Production by Counties ---- 116, 117, 118
Gas vs. Electricity ---- 242
Gasoline—
  Bibliography ---- 500
  Casing Head ---- 113
  From Gas ---- 113, 254
Gauging of Tanks ---- 106
General Petroleum Co. ---- 14, 17, 29, 30, 44
General Pipe Line Co. ---- 94, 486
Geological Names ---- 21
Geology—
  Beverly Hills ---- 357
  Bibliography ---- 500
  Brea Canon ---- 359
  Burrel Point ---- 364
  Chino Region ---- 364
  Coalinga ---- 131
  Coyote Hills ---- 362
  Fullerton-Olinda Field ---- 360
  Kern River ---- 196
  La Habra Field ---- 361
  Los Angeles and Orange Counties ---- 350
  Los Angeles City ---- 354
  Los Angeles, Northern ---- 381
  McKittrick ---- 292
Monterey, San Luis Obispo and San Benito Counties ---- 418, 436
  Midway-Sunset ---- 226
  Newport Region ---- 365
  Puente Hills ---- 359
  Salt Lake ---- 355
  San Pedro Region ---- 366
San Joaquin Valley, South End ---- 466

PAGE.
San Joaquin Valley, West Side north of Coalinga 465
    Santa Maria 403
    Summerland 416
    Use of 19
Vallecitos District 465
    Ventura County 381
    Whittier 358
Gravity of Oil—
    Midway-Sunset 222
    Santa Maria and Lompoc 399
    Whittier-Fullerton 314
Harmon, A. K. P., Jr. 455
Hauling, Cost 157
Heating Value of Oil 82
History of Development—
    Coalinga 121
    Kern River 202
    Lost Hills, Belridge 305
    McKittrick 292
    Midway-Sunset 217
    Santa Barbara County 396
    Santa Maria Field 396
    Sunset 257
    Ventura County 368
Hopper Canyon, Geology 390
Huasna District, Geology 430
Humboldt County—
    Bibliography 501
    Gas Statistics 117
    Geology and Oil Possibilities 444
Igneous Rocks, definition 20
Imperial County, Oil Possibilities 459
Imports of Oil 95
Independent Oil Producers Agency 16, 37, 38, 39
Introduction 3, 4
Inyo County, Geology, Mojave Desert 460
Jacalitos Formation 134, 228, 423
Kern County—
    Bibliography 501
    Gas Statistics 118
    Geology, Mojave Desert 460
    Oil Production since 1894 307
Kern River Field—
    Bibliography 501
    Geology 196
    Monthly Statistics 205
    Topography 195
Kern Trading and Oil Co. 14, 17, 29, 30, 43, 44
Kettleman Hills 124
Kings County—
    Bibliography 501
    Gas Statistics 118
Kirwan, M. J. 14
Kreyenhagen Field 123
La Habra Field—
    Bibliography 501
    Geology 361
Lake County—
    Bibliography 502
    Oil and Gas Occurrences 460
Land, Area per well 13
Land Value, Method of Computing 155
Latham, E. B. 14
Legislation, Bibliography 502

Life of Wells— PAGE.
  Coalinga 169
  East of Los Angeles 317
  Midway-Sunset 266
  Santa Maria 402
  Ventura 371
Logs, System of keeping 141
Lompoc Field—
  Bibliography 502
  Financial Results, 1913 414
  Monthly Statistics 410
Los Angeles City Field—
  Geology 354
  Monthly Statistics 312, 320
Los Angeles County—
  Bibliography 502
  Conclusions in Regard to Oil Accumulations 366, 395
  Gas Statistics 117
  Geology 350, 381
Los Angeles Field—
  Bibliography 502
  Natural Gas 255
Los Gatos Region, Geology 469
Lost Hills Field 302
  Bibliography 502
  Monthly Statistics 306
Maps of Fields 14
Marin County—
  Bibliography 502
  Geology and Oil Possibilities 473
Marketing Companies 9, 15
Marketing of Oil 29
Martinez Formation 383
Matilija Region, Geology 388
McFadden, R. J. 14
McKittrick Field 291
  Bibliography 502
  Monthly Statistics 295
Mendocino County, Bibliography 502
Merrill, F. J. H. 459, 467
Metamorphic Rocks, definition 20
Midway Field—
  Bibliography 502
  Monthly Statistics 223
Midway, Financial Results, 1913 225
Midway-Sunset, Geology 226
Mojave Desert Region, Geology and Oil Possibilities 460
Monocline, definition 22
Mono County 463
Monopoly of Oil Land 15
Monterey County—
  Bibliography 502
  Geology 418, 436
Monterey Formation 226, 292, 352, 386, 422
  Definition 385, 386
Monterey Series 352, 385
  Definition 385
Moody's Gulch 469
Movement of Oil, underground 59
Murphy Oil Co. 490
Napa County—
  Bibliography 503
  Oil Indications 460
Newhall, Operating Companies 380
Newhall-Pico, Monthly Statistics 375
Newhall Region, Geology 392

PAGE.
Newhall Region, Monthly Statistics 375
Newport Region, Geology 365
Oil City Field 121
Oil Resources, summary 13
Oil Sand, definition 23
Ojai Valley Region, Geology 388
Olinda Field, Geology 360
Operating Companies. (See Companies Operating.)
Operating Cost 9
Orange County 308
  Bibliography 503
  Conclusion 366
  Gas Statistics 118
  Geology 350
Origin of Petroleum 24, 200
Ownership of Proved Oil Land 16
Panama, Oil used at 84
Parkfield District, Geology 425
Paso Robles Formation 423
Peckham, S. F. 368
Perforation of Casing 152
Physical and Chemical Properties 84
  Bibliography 504
Pico Canyon, Statistics 375
Pinal-Dome Oil Co. 489
Pipe Lines 87, 91
Pipe Lines, Construction cost 89, 90
Pipe Lines, Railroad Commision Investigation 475
Pleistocene 387
Pleyto District, Geology 435
Possible Oil Land, Los Angeles and Orange Counties 367
Power—
  Drilling 153
  Required to pump wells 159, 246
Price of Oil 9, 49, 55, 56
Prŏducers Transportation Co. 481
  Pipe Lines 92
Producing Companies 9
Producing Wells 13
Production—
  Bibliography 503
  By Marketers 15
  Cost, Los Angeles vicinity 346
Production Diagrams, Coalinga, summary 188
Production Diagrams, explanation 57
Production Diagrams, Midway-Sunset 267
Productive Capacity of Oil Sand 57
Proved Land—
  Midway-Sunset 222
  Ownership 14, 16
  Santa Maria and Lompoc 399
  Whittier-Fullerton 314
Proved Oil Land 13
Public Utilities Act, Oil Pipe Lines 476
Puente Field—
  Geology 359
  Monthly Statistics 337
Puente Formation 352, 386
  Definition 386
Pumping—
  Bibliography 503
  Cost 158, 301
  Cost, Los Angeles 346
  Cost, Midway 242, 243, 244, 245
  Cost, Salt Lake 347

PAGE.

Pumping—Continued.
  Cost, Santa Maria 416
  Kern River 212
Pumping of Oil in Pipes 87
Pumping Wells, power 159
Railroad Commission of California 29
  Pipe Line Investigation 475
Railroads—
  Shipments by 99
  Use of Oil 84
Refining 107
  Bibliography 504
Repair of Wells 160
  Cost 301
Reservoirs 101, 102, 103
Rotary Tools 152
Royal Dutch Shell Co. (See Shell Co. of California.) 45
Sacramento County—
  Bibliography 504
  Gas Statistics 117
Salt Lake Field 313, 315
  Bibliography 504
  Geology 355
  Monthly Statistics 329
  Possible Extension 356
  Pumping Cost 347
Salt Lake Oil Co. 488
Sampling Oil, Bibliography 504
San Ardo District, Geology 434
San Benito County—
  Bibliography 505
  Geology 418, 436
San Bernardino County—
  Bibliography 505
  Geology, Mojave Desert 460
San Diego County—
  Bibliography 505
  Geology and Oil Possibilities 467
San Joaquin County—
  Bibliography 505
  Gas Statistics 116
San Joaquin Valley—
  West Side, North of Coalinga 465
  South End, Geology 466
San Lorenzo District, Geology 424
San Luis Obispo County—
  Annual Statistics 436
  Bibliography 505
  Geology 418, 430
San Mateo County—
  Annual Statistics 471
  Bibliography 506
  Geology and Oil Possibilities 468
San Pedro, Geology 366
Santa Barbara County 396
  Annual Statistics 412
  Bibliography 506
  Gas Statistics 116
Santa Clara County—
  Bibliography 506
  Gas Statistics 116
  Geology and Oil Possibilities 468
  Statistics, Annual 471
Santa Cruz County, Bibliography 506
Santa Fe Railroad 17, 29, 30, 45
Santa Margarita Formation 133, 228, 422

Santa Maria Field— PAGE.
  Bibliography 506
  Companies Operating 413
  Financial Results, 1913 414
  Geology 403
  Monthly Statistics 408
Santa Paula Ridge, Geology 389
Sargent Ranch Field 470
Sedimentary Rocks, Definition 21
Sespe Canon, Geology 390
Sespe Formation 384
Shasta County, Bibliography 506
Shell Company of California 45
Shell, Definition 23
Shipments by Producers 46, 47
Shipping, Bibliography 506
Sisar Creek, Geology 389
Solano County 472
  Bibliography 506
  Gas Statistics 117
Sonoma County—
  Bibliography 507
  Geology and Oil Possibilities 472
Southern Pacific R. R. (See Kern Trading & Oil Co.)—
Specific Gravity 81
Stalder, Walter 444
Standard Oil Co. 14, 16, 29, 30, 31, 32, 33, 49, 104, 205, 218, 220, 223, 257, 261, 294, 305, 306, 308, 326, 334, 337, 340, 369, 370, 372, 408, 434, 480
Standard Oil Co., Pipe Lines 92
Standard Tools 152
Statistics, Annual—
  Fresno County 124
  Kern County 307
  Los Angeles County 317
  Orange County 317
  San Luis Obispo County 438
  Santa Barbara County 412
  Ventura County 371
Statistics, Monthly 53
  Arroyo Grande 433, 434
  Coalinga 127, 128, 129
  Fullerton-Brea Canon 340
  Kern River 205
  Lompoc 410
  Los Angeles City 326
  Lost Hills 306
  McKittrick 296
  Midway 223
  Newhall and Pico 375
  Puente 337
  Salt Lake Field 329
  Santa Maria 408
  Sunset 261
  Ventura 372
  Whittier 334
  Whittier-Coyote 336
  Whittier-Fullerton 331, 332
Steam Power 247
Steam, Power for Pumping 162
Steam Power Plants 161
Storage, Bibliography 507
Strike, Definition 23
Structure, Definition 22
Sulphur Mountain, Geology 389
Summerland 416
Summerland, Financial Results, 1913 414

PAGE.

Sunset Field—
  Bibliography 507
  Companies Operating 264
  Development and Productiveness 257
  Financial Results, 1913 259
Sunset Flat 219
Sunset, Monthly Statistics 261
Syncline, Definition 22
Table of Contents 5, 6
Tanks 104
  Bibliography 507
  Fire In 104
  Measurement 106
  Specifications 105, 106
Tank Vessels 98, 99
Teams 158
Tejon Formation 131, 383
Tejon Hills 471
Temblor Formation 422
Temperature Corrections 79
Topography, Kern River 195
Top Water, Definition 23
Total Field Production 13
Tour, Definition 153
Traction Engines 157
Transportation—
  Bibliography 507
  By Rail 99
  By Ship 91
  By Water 98, 99
  Cost 90, 91
Tulare County—
  Bibliography 507
  Gas Statistics 118
Tulare Formation 153, 228, 423
Unconformity, Definition 23
Union Oil Co. 14, 16, 29, 30, 34, 35, 36, 487
Union Oil Co., Pipe Lines 93
Universal Oil Co. 14
Uses, Bibliography 507
Uses of Oil 84
Vallecitos District 465
Valuation, Bibliography 507
Value of Oil Land, Method of Determining 155
Vaqueros Formation 133, 352, 386, 422
  Definition 386
Ventura County 368
Bibliography 508
  Conclusions in Regard to Oil Accumulation 395
  Financial Results, 1913 378
  Gas Statistics 117
  Geology 381
  History of Development 368
  Monthly Statistics 372
  Operating Companies 379
  Rate of Development and Production 370
  Statistics, Annual 371
Ventura River Region, Geology 388
Water—
  Analysis at Coalinga 160
  Bibliography 508
Water in Oil Wells—
  Coalinga 189
  Midway-Sunset 288
  Whittier-Fullerton 317
Water Raised by Air 213, 215

	PAGE.
Water Sand, Definition	23
Water, Transportation by	98
Water, Treatment for Boilers	160
Weight of Oil	81
Well—	
Deepest	355
Humboldt County	453
Life of	169
Ownership	14, 16
Repairs	242
Ventura County	392
West Side Field, Coalinga	122
Wheeler Ridge Region	466
Whittier-Coyote, Monthly Statistics	336
Whittier Field	310
Bibliography	508
Geology	358
Monthly Statistics	334
Whittier-Fullerton Field	309, 314
Monthly Statistics	331
Yolo County, Bibliography	514

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